COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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Huge Tubular-Type Air Heater; see page 62

Appraisal of Preferred Standards for Large Turbine-Generators ▶

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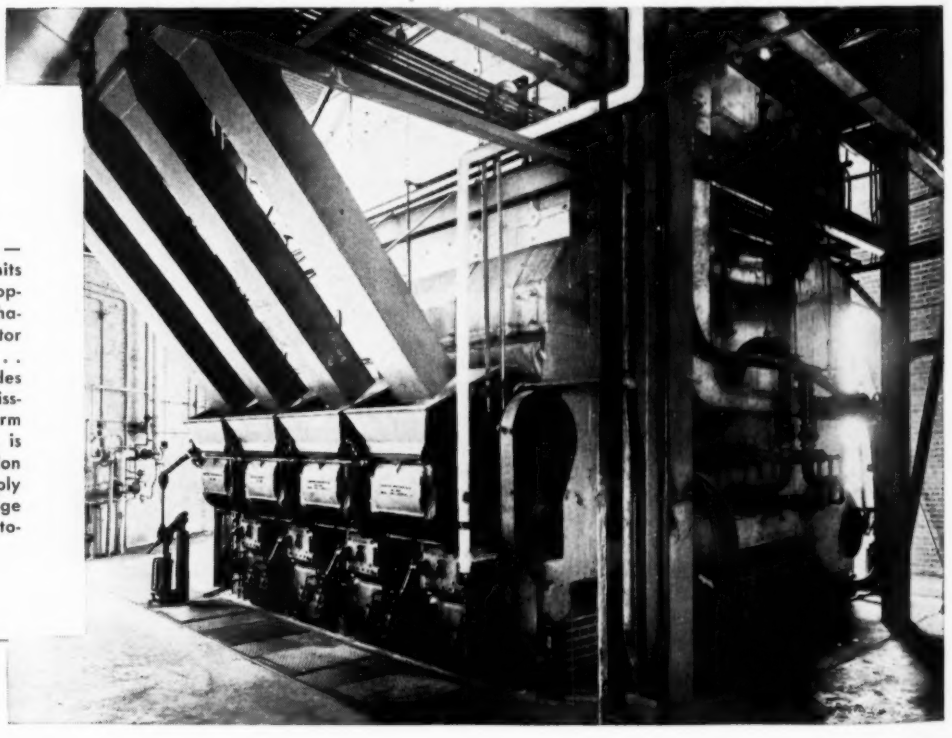

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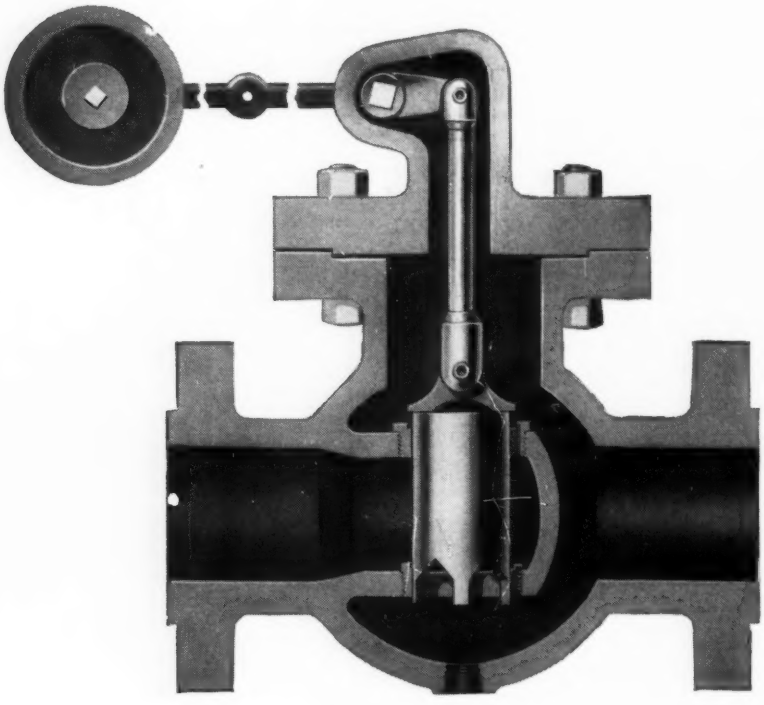

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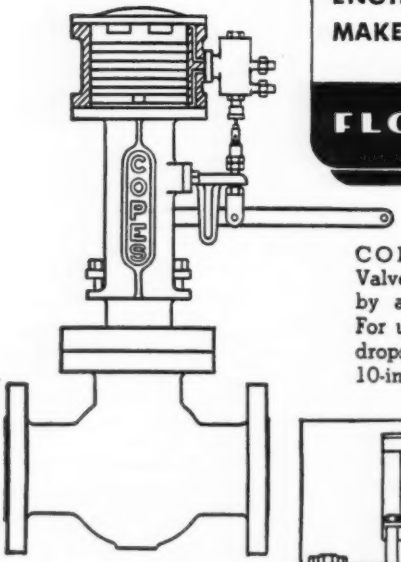

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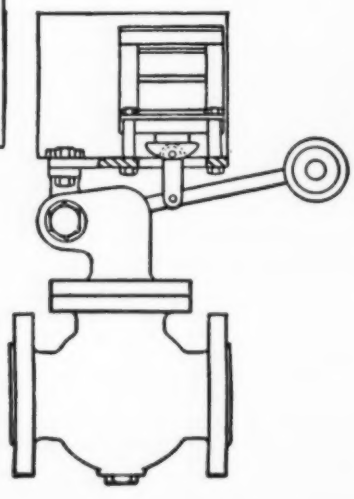

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Editorials

A Tribute to the Project Manager

A new power plant goes on the line. Perhaps there is a formal dedication ceremony accompanied by oratory and inspection tours by visiting dignataries. But one man remains inconspicuously in the background. He is what many consulting engineering firms designate as the project manager, the engineer who is directly responsible for the overall design, scheduling and—ofttimes—the construction of a power plant.

True it is that he is but one member of a team which, in the case of large central station projects, may include several hundred engineers, draftsmen and kindred associates. But the project manager is the captain of that team. It is he who guides the evolution of a power plant from the nebulous figures of long-range load forecasting through the engineering report stage, on to the selection and purchase of equipment and the planning and coordination of design, then to scheduling, expediting and construction, and finally to the testing and acceptance of the completed plant.

The project manager is the one who is unrelentingly pursued by enterprising vendors, who attempts to keep the client contented and satisfied while staying within his own organization's budgetary limitations, and who learns much about human vanity and pride—especially when an individual's pet ideas involve special quirks of engineering design.

As the captain of a team, the project manager must be a diplomat, but at the same time his actions must be decisive and clear cut. He must have a broad grasp of power plant engineering, but he must not be so enamored by his own ideas that he finds difficulty in fairly evaluating the suggestions that will freely come his way. At times he must act as a quiescent buffer between the client and his own management, enjoying the confidence of both. He must be a master of conference technique and an indefatigable memo writer. Obviously, he must be able to plan, to arbitrate and to coordinate. But above all he must be able to get things done—and get them done in time at a cost that can be justified.

Yes, behind the pounds of steam and kilowatts of electricity of the recently dedicated power plant is the man who convinced the structural engineer that piping routing was as important as column-location symmetry, the man who made the recommendation that L. P. Bilg & Co. should receive the insulation contract instead of P. L. Glib & Co., the man who insisted that a certain valve be delivered on schedule—or else, and the man who can still smile after a careless workman has caused the new station to trip out during its maiden test run. It is he who has obtained authorization and given approval for extra expenditures and overtime work, who rationalized the architect's sense of esthetics with the electrical engineer's utilitarian objectives, and who still managed to find a little time for the enjoyments of life.

The project manager is the unsung hero of many power plants. May this tribute remind those who are not cognizant of his duties and accomplishments that the project manager is a most vital element in the chain that links load forecasting to the production of kilowatts.

Age of Boilers

What should be considered the active life, or age of retirement of a boiler? The answer perhaps is not as simple as in the case of humans where, despite exceptions, the present widely accepted age is 65. With a boiler much depends upon proper maintenance, although an equally important factor is its adequacy to meet present-day demands economically—in other words, obsolescence often outweighs physical condition.

Yet in these days when so much is being written concerning modern large high-pressure, high-temperature steam generating units, one is likely to lose sight of the large number of old boilers still plodding along in utility plants. While few may be doing base load service, they are nevertheless playing an important part in enabling electrical demands to be met at some sacrifice in economy.

Of interest in this connection is a survey conducted by the Federal Power Commission and published earlier this year under the title "Steam-Electric Plant Construction Costs and Annual Production Expenses," which lists data on the 200 more important electric generating stations in the United States, excluding those that have gone into service since 1947. Nearly a third of the number of boilers in these plants are 25 years or older. While, individually, they are relatively small, compared with modern steam generators, their aggregate rating exceeds 13 million pounds of steam per hour.

Presumably when central station capacity has been built up to exceed peak demands by a safe margin, most of these older units will be retired; but until then, they must be regarded as an economic liability.

No comparable figures are available concerning the age of boilers in industrial power plants, but when one considers the long depression period of the Thirties, followed by war years during which only limited replacements were possible, it can be assumed that the industrial power plants contain much outmoded steam generating equipment.

An Appraisal of the Preferred Standards for Large 3600-Rpm Steam Turbine-Generators

By A. G. CHRISTIE*

ENGINEERS are in general agreement that apparatus can be built at lower first cost and in less time when made in certain standard sizes rather than when "tailor-made" to the purchaser's particular specifications. This principle has been applied to the manufacture of automobiles, tractors, farm machinery, motors, electric lamps and numerous other articles of commerce. At first, there was considerable reluctance to apply the same principles to the construction of power plant equipment, but certain "Preferred Standards" for large 3600-rpm condensing steam turbine-generators were adopted in 1945. The following paragraphs are intended to appraise the acceptance of such units in American power plants.

The results of a survey directed to representative power plant designers and turbine builders indicate that, making allowance for special conditions, the Preferred Standards have been well received; that so far they have not reflected appreciably lower costs or shorter deliveries, an objective that may be attained with a slowing down of orders; that extension of the Standards to units larger than 60,000 kw may be desirable; and that a review of the throttle conditions for the larger sizes may be in order. There is not full agreement as to the economics of the greater capability for the non-standard units.

Certain standards for steam turbine-generators, both condensing and non-condensing, with ratings 10,000 kw and above, were first adopted in 1939 by the National Defense Power Committee. These standards were modified in 1943 for turbines operating at 3600 rpm by a committee of the American Society of Mechanical Engineers. This committee's recommendations met with a favorable reception and as a result a joint committee of representatives of the American Institute of Electrical Engineers and of the American Society of Mechanical Engineers was formed to prepare complete standards for the selected ratings of turbine-generators. The report of this joint committee was approved by both sponsor organizations and "Preferred Standards" were announced in 1945. In the meantime, the turbine builders had been developing designs in conformity with these standards. Simultaneously, with the publication of the Preferred Standards in 1945, these builders announced that they were prepared to accept orders for standard units.

Designs were completed for the different ratings in the Preferred Standards with the exception of the 15,000-kw unit which, for some reason, was not at first in demand. The subsequent rise in coal prices made it desirable to develop a unit of 15,000 kw rating with better economy than possible with the steam conditions originally contemplated. Early in 1949, the characteristics of the 15,000 kw size were revised to specify steam conditions of 850 psig, 900 F instead of 600 psig, 825 F, originally selected; at the same time the generator cooling medium was changed from air to hydrogen. Both changes led to a design with a lower fuel consumption in Btu per kwhr than with the original conditions. Table 1 gives the Preferred Standards of today.

The original Preferred Standards were discussed in an article in COMBUSTION, April 1945, where the objectives of such standardization were stated as follows: "Compared with non-standard units, first costs of standard units should be less, shorter time between order date and delivery should be possible, standard layout drawings should be available when orders are placed instead of the delays when these have to be made after receipt of an order, and, finally, standard performance data in Btu per kwhr should be immediately available to prospective buyers for preliminary studies." In general, it was expected that standardization of these turbine-generators would lead to lower installation cost not only of the unit itself but also would reduce engineering costs connected with the plant design. It was also hoped that standard saturated steam temperatures at the extraction points of these standard units with standard steam conditions would make possible the development of standard feedwater heaters and pumps. It was even hoped that some degree of standardization of steam generators might be achieved.

Within the range of the Preferred Standards a large capacity of standard and non-standard turbine-generators has been purchased since 1945. A request has been made for an analysis of the results of such standardization, and to indicate further action that may be desirable in view of present conditions and trends.

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The following set of questions was sent to a representative group of power plant designers and similar questions were submitted orally and by correspondence to turbine manufacturers. The latter were also asked for statistical data. The questions were:

(1) In your experience, do the Preferred Standards meet the need of your company or companies with which you deal within the ranges of these Standards?

(2) Do you consider that throttle conditions should be increased for larger Standard units and, to what figures?

(3) Do you find that the increased capability of 25 per cent in non-standard units can be capitalized at a lower figure than the 10 per cent added capability of the Preferred Standard turbines?

(4) Do you find a sufficient differential in price in favor of the Preferred Standard units?

(5) Does the time seem propitious for the joint A.I.E.E-A.S.M.E. Committee on Turbine Standardization to choose a Preferred Standard larger than 60,000 kw—say 90,000 kw?

(6) Is it possible to standardize reheat units for a limited number of sizes? Do you consider that reheat units will be installed to an increasing extent in the near future?

(7) Does the lower average cooling water temperature in the North favor tailor-made units with larger exhaust annuli than Preferred Standard units?

The comments on these questions, both written and oral, were quite extensive and complete. The following paragraphs presenting a summary of these comments, may be considered as representative of present American opinion on turbine standardization.

Regarding the first question, there is quite general agreement that the Preferred Standard units meet the needs of the several companies within the capacity range of these standards except where high fuel costs may favor reheat units or elevation of steam conditions beyond those specified in the Standards. One must recognize that many non-standard turbine-generators with ratings between 11,500 and 60,000 kw have been purchased as additions to stations in which non-standard units were installed prior to 1945. Also, some non-standard sets in this capacity range have been purchased for reheat. It appears that new stations are being furnished with Preferred Standard units except where reheat is used or local conditions are unusual.

It is generally agreed in considering question No. 2 that the throttle conditions of the Preferred Standard units below 60,000 kw rating are satisfactory and should not be changed. Several engineers suggest that an alternate set of higher steam conditions should be specified for the 60,000 kw rating in view of the desirability of a lower heat rate with the increased price of coal. They suggest 1450 psig, 1000 F or 1050 F and that the specification of 850 psig, 900 F be dropped and the optional conditions of 1250 psig, 950 F be retained.

Relative Capabilities

Question No. 3 led to lengthy discussions of the capabilities of Preferred Standard and non-standard turbine-generators. Full consideration has not always been given to certain of the involved factors. Preferred Standard turbines have a capability 10 per cent above the nominal kilowatt rating but the generators at normal hydrogen pressure of 0.5 psig, are specified for 85 per cent power factor or for a rated kva which is 17.6 per cent above the nominal kilowatt rating. This generator thus has a rated kva capability which is about 7 per cent above the guaranteed capability of the turbine. This may be regarded as the extra "cushion" built into this generator.

However, another factor needs consideration. The last note under Table 1 states that the "turbine capability" is the guaranteed continuous output at generator terminals with 2.5 in. Hg absolute exhaust pressure. The designs provide for a flow of steam through the first stage of the turbine that is sufficient to develop its full capability with 2.5 in. Hg absolute back pressure. This exhaust pressure was chosen so that the Preferred Standard units could deliver full capability with the warm cooling water that must be used in the condensers of southern power plants in summer. A considerable increase in capacity is possible when operating with lower absolute back pressures than 2.5 in., even after allowing for increased leaving losses. When cold cooling water is available to the condenser turbine capability will be greater than 10 per cent above rating and may equal the kva rating of the generator with 100 per cent power factor and normal hydrogen pressure. Thus, the "cushion" of the generator may be fully utilized for a large portion of the year.

Non-standard turbine-generators are generally specified with a nominal rating in kilowatts at 80 per cent power factor on the generator. The turbines have a guaranteed capability of 25 per cent above the nominal kilowatt rating. Operation at a load corresponding to guaranteed turbine capability, therefore, requires operation of the generator at 100 per cent power factor if rated kva and normal hydrogen pressure are not exceeded.

TABLE 1—PREFERRED STANDARDS FOR LARGE 3600-RPM, 3-PHASE, 60-CYCLE CONDENSING STEAM TURBINE-GENERATORS

	Air-Cooled Generator	Hydrogen-Cooled Generators Rated for 0.5 Psig Hydrogen Pressure				
Turbine-generator rating, kw	11,500	15,000	20,000	30,000	40,000	60,000
Turbine capability, kw	12,650	16,500	22,000	33,000	44,000	66,000
Generator rating, kva	13,529	17,647	23,529	35,294	47,058	70,588
Power factor	0.85	0.85	0.85	0.85	0.85	0.85
Short-circuit ratio	0.8	0.8	0.8	0.8	0.8	0.8
Throttle pressure, psig	600	850	850	850	(850) or (1250)	(850) or (1250)
Throttle temperature, F	825	900	900	900	(900) or (950)	(900) or (950)
Number of extraction openings	4	4	4	5	5	5
Saturation temperatures at openings at "turbine-generator rating" with all extraction openings in service, F						
1st	175	175	175	175	175	175
2nd	235	235	235	235	235	235
3rd	285	285	285	285	285	285
4th	350	350	350	350	350	350
5th	...	...	...	410	410	410
Exhaust pressure, in Hg abs.	1.5	1.5	1.5	1.5	1.5	1.5
		Hydrogen-Cooled Generator Operated at 15 Psig Hydrogen Pressure				
Generator capability at 0.85 power factor, kva	...	20,294	27,058	40,588	54,117	81,176

A tolerance of plus or minus 10 F shall apply to above saturation temperatures. (Tolerances shall be unilateral so as not to reduce the spread in temperature between adjacent extraction openings.)

The "turbine capability" is guaranteed continuous output at generator terminals when the turbine is clean and operating under specified throttle steam pressure and temperature and 2.5 in. Hg abs. exhaust pressure, with full extraction from all extraction openings.

Such generators do not have any "cushion" as in the case of Preferred Standard generators since they have no margin in kva above the turbine capability.

Obviously, the non-standard generator for the same nominal turbine rating in kilowatts and the same hydrogen pressure, is a larger unit by about 6.3 per cent than the Preferred Standard generator and should, therefore, cost more to build. The non-standard turbine has a capability about 13.6 per cent greater than a Preferred Standard unit of the same nominal kilowatt rating. In order to use the full capability of such a non-standard turbine the sizes of steam generator, heaters, boiler feed pumps, piping, condensers and condenser auxiliaries must be greater than for a Preferred Standard installation. In other words, the non-standard unit requires a larger station to provide its full capability than is needed by a Preferred Standard set.

Comparable Costs Difficult

While some power plant designers believe that the installed cost per kilowatt of the non-standard unit plant with its greater capability is less than for a Preferred Standard unit station, the majority think that lower costs per kilowatt are possible where Preferred Standard units are installed. All agree that relative costs of strictly comparable plants which include Preferred Standard and non-standard units are difficult to estimate accurately and, due to local differences in costs of construction and other factors, will be open to question as conclusive findings.

The preceding comments apply to generators with the same normal hydrogen pressure of 0.5 psig, as specified in the Preferred Standards. The kva capacity of all generators can be increased by boosting the hydrogen pressure and thereby providing added generator capacity at full load. This is evident in Table 1, when the hydrogen pressure is increased to 15 psig.

A further consideration in the comparison of Preferred Standard and non-standard units rated at 60,000 kw is the probability that each will use the same maximum length of blades in the last low-pressure row. With the same blade length the greater capability of the non-standard turbines leads to increased leaving losses at maximum capability which will be approximately 30 per cent greater than the leaving losses of the Preferred Standard turbine at its maximum capability. Hence, the heat rate of the non-standard unit at maximum capability must be greater than that of the Preferred Standard turbine at its maximum capability.

An original object of standardization was to decrease the first cost of the Preferred Standard turbine-generators below the price of similar non-standard units since the former could be built on a quantity production basis. There has been some differential in prices between Preferred Standard and non-standard sets but replies to question No. 4 indicated that purchasers are in general agreement that the price differential should be greater than at present. Without having access to actual manufacturing costs, it can be said in fairness to the turbine builders that conditions since 1945 have not been favorable for the production of turbine-generators at minimum cost. Labor rates have increased rapidly over this period and at the same time, labor efficiency is said to have decreased. Steel has often been in short supply and its cost has increased. Strikes have occurred in the plants. At the end of the War the turbine builders were flooded with orders for new units. The manufacturers were forced to place the Preferred Standard and non-standard purchases on their production schedule in the order in which they were received so that all buyers were given equal treatment. This intermingling of types in the shopes required continual changes of machine set-ups and of instructions to workers; all of which are not conducive to low production cost. The expected benefits of repetitive manufacture of Preferred Standard units could not be fully realized under these conditions. When the present shortages of system capacity have been overcome it should be possible to lower the shop costs of Preferred Standard units and to shorten the time between placing the order and delivery of the completed unit.

In the case of at least one of the manufacturers, it is of interest to note the changes since 1945 in the time required between placing of an order and delivery of the turbine-generator. At the beginning of 1946 the promised time was 21 months but units ordered early in 1947 required 36 months. Those purchased in 1948 were expected to require 34 months. At present, one can obtain estimates of delivery in less than two years after placing the order. This indicates that manufacturers are catching up on orders and that normal production conditions should prevail shortly.

No Gain in Delivery Time

While delivery time of Preferred Standard units has not been shorter than for non-standard units, certain other advantages have been gained. The turbine manufacturers have computed and published complete tables of the expected performances of Preferred Standard turbine-generators. These shorten the time required for preliminary plant studies and for estimating the required capacities of steam generators, piping, heaters, condensers, pumps and other auxiliaries. This compares with the usual delay in obtaining performance data for non-standard machines unless these are duplicates of earlier installations.

Turbine builders have also prepared plans for Preferred Standard units which show over-all dimensions, foundation loadings, piping and exhaust sizes and location, and other data. These plans are available with the placing of an order and serve to expedite station design. Some changes have been made from time to time in such standard plans which have been annoying to purchasers, as these changes have resulted in delays in the completion of plant designs and have thereby increased engineering costs. The turbine builders state that the designs of the Preferred Standard units were prepared during the war-time rush. Subsequent study, construction and operating experiences, and later engineering developments have indicated certain improvements which have been incorporated in the present designs to improve reliability, efficiency and operating convenience. Most of such changes have now been made and plans are becoming stabilized.

Different opinions were expressed regarding question No. 5. Some engineers hold that the provision of a Preferred Standard of larger nominal rating than 60,000 kw is not desirable as the high fuel costs at present justify a "tailor-made" non-standard turbine of large capacity which would be designed to achieve the highest possible economy under the local plant conditions of load, throttle

TABLE 2—SALES OF TURBINE-GENERATORS

	Allis-Chalmers Mfg. Company*			General Electric Company			Westinghouse Electric Company		
	Preferred Standard	Non-Standard	Total	Preferred Standard	Non-Standard	Total	Preferred Standard	Non-Standard	Total
1946									
Number of units	..	..	..	23	45	68	23	27	50
Per cent of number	25	75	..	33.8	66.2	....	46	54	....
Total rated capacity, kw	..	..	..	933,000	1,446,250	2,379,250	1,090,000	710,000	1,800,000
Per cent of capacity	27.6	72.4	..	39.2	60.8	....	60.5	39.5	....
1947									
Number of units	..	..	..	21	24	45	37	15	52
Per cent of number	50	50	..	46.6	53.4	....	71.1	28.9	....
Total rated capacity, kw	..	..	..	793,000	970,000	1,763,000	1,383,000	517,500	1,900,500
Per cent of capacity	68.8	31.2	..	45	55	....	72.7	27.3	....
1948									
Number of units	..	..	..	12	23	35	14	9	23
Per cent of number	28.6	71.2	..	34.3	65.7	....	60.8	39.2	....
Total rated capacity, kw	..	..	..	561,500	700,000	1,261,500	484,500	200,000	684,500
Per cent of capacity	54.8	45.2	..	44.5	55.5	....	70.8	29.2	....
Total 1946–1948									
Number of units	..	..	..	56	92	148	74	51	125
Per cent of number	36	64	..	37.2	62.8	....	59.2	40.8	....
Tolerated capacity, kw	..	..	..	2,287,500	3,116,250	5,403,750	2,957,500	1,427,500	4,385,000
Per cent of capacity	53.6	46.6	..	42.3	57.7	....	67.4	32.6	....

* Allis-Chalmers Mfg. Co. according to company policy, did not release for publication either the number of units or their total capacity.

conditions and cooling water temperature. The majority appear to believe that a Preferred Standard unit of 90,000 kw normal rating, 99,000 (or 100,000) kw capability built for 1450 psig, 1050 F should be considered at this time.

Question No. 6 was prompted by the increased number of reheat units that have been purchased recently. The majority of engineers consulted state that consideration should be given to fixing standards for a few ratings of reheat units up to capability of 100,000 kw. It is proposed that the steam conditions for such reheat units should be 1450 psig, 1000 F and 1000 F reheat.

Effect of Latitude

With reference to the last question, when the Committee was making a selection of exhaust conditions for Preferred Standard units, a compromise had to be made between the desires of users in northern and southern sections of the country. This led to the selection of a standard absolute pressure of $1^1/_2$-in. of mercury for performance estimates. The gain in station economy from the full utilization of an additional inch of vacuum with adequate exhaust areas and with cold northern waters at the time of the winter loads, is quite substantial. This gain in some cases may justify non-standard units with larger exhausts to care for such vacuum. Triple exhausts may be required on larger 3600 rpm units in such cases which would lead to increased first cost of the turbine. With higher coal prices increased first costs may be justified for the increased efficiency from the best possible vacuum. One must, therefore, equate the savings in fuel under the given load conditions against the increased capital charges on the non-standard units.

The three larger turbine builders were asked for data on the number of Preferred Standard and non-standard turbine generators and their total respective capacities sold in 1946, 1947 and 1948. These totals cover only 3600 rpm units within the range of the Preferred Standard sizes, viz., 11,500 to 60,000 kw ratings. Table 2 summarizes these data.

With reference to Table 2, complete data are not available regarding the number of non-standard units which were duplicates of those already installed in the purchaser's plants. Such figures as are at hand indicate that over one-third of the non-standard units are such duplicates. Other non-standard units include reheat units, topping turbines and non-condensing sets. When allowance is made for these several classifications, the number and total capacity of non-standard units purchased for new plants probably would not equal one-half of the total non-standard units. Attention is directed to the large capacity of non-standard units purchased in 1946.

From the data in Table 2 and from other figures at hand, it appears that about 47 per cent of the total number of turbine-generators purchased in 1946, 1947 and 1948 were Preferred Standards with about 53 per cent non-standard. However, the figures are reversed when total rated capacities are considered, for about 53 per cent of the total rated capacity purchased represents Preferred Standards and about 47 per cent non-standard. These figures lead to the deduction that the average rated capacity of the Preferred Standard units purchased is about 40,000 kw while the average of the non-standard sets is about 30,000 kw. Evidently a considerable number of the non-standard units were of the smaller capacities. On the other hand, a considerable number of Preferred Standard units of 60,000 kw rated capacity were purchased during this period.

It is interesting to note in connection with standarization of turbine-generators that a subcommittee of the International Electrotechnical Commission met recently in Belgium to discuss the standardization of 50-cycle turbine-generators along similar lines to the Preferred Standards given in Table 1.

Conclusions

The evidence at hand indicates that the Preferred Standards have been well received when allowance is made for repeat orders, topping units and non-condensing sets among the non-standard purchases. It may be desirable to review throttle conditions for the larger sizes of units in view of higher coal prices. There are doubts about the economics of the greater capability of the non-standard turbine-generators. The rush to purchase new turbine-generators is slowing down as evidenced by more prompt deliveries. As a result many purchasers believe that it should be possible to effect savings in the manufacture of Preferred Standard units and that a greater part of these savings should be passed on to the customer in an increased differential in price between Preferred Standard and non-standard units. A larger Preferred Standard unit than 60,000 kw appears to be needed. The

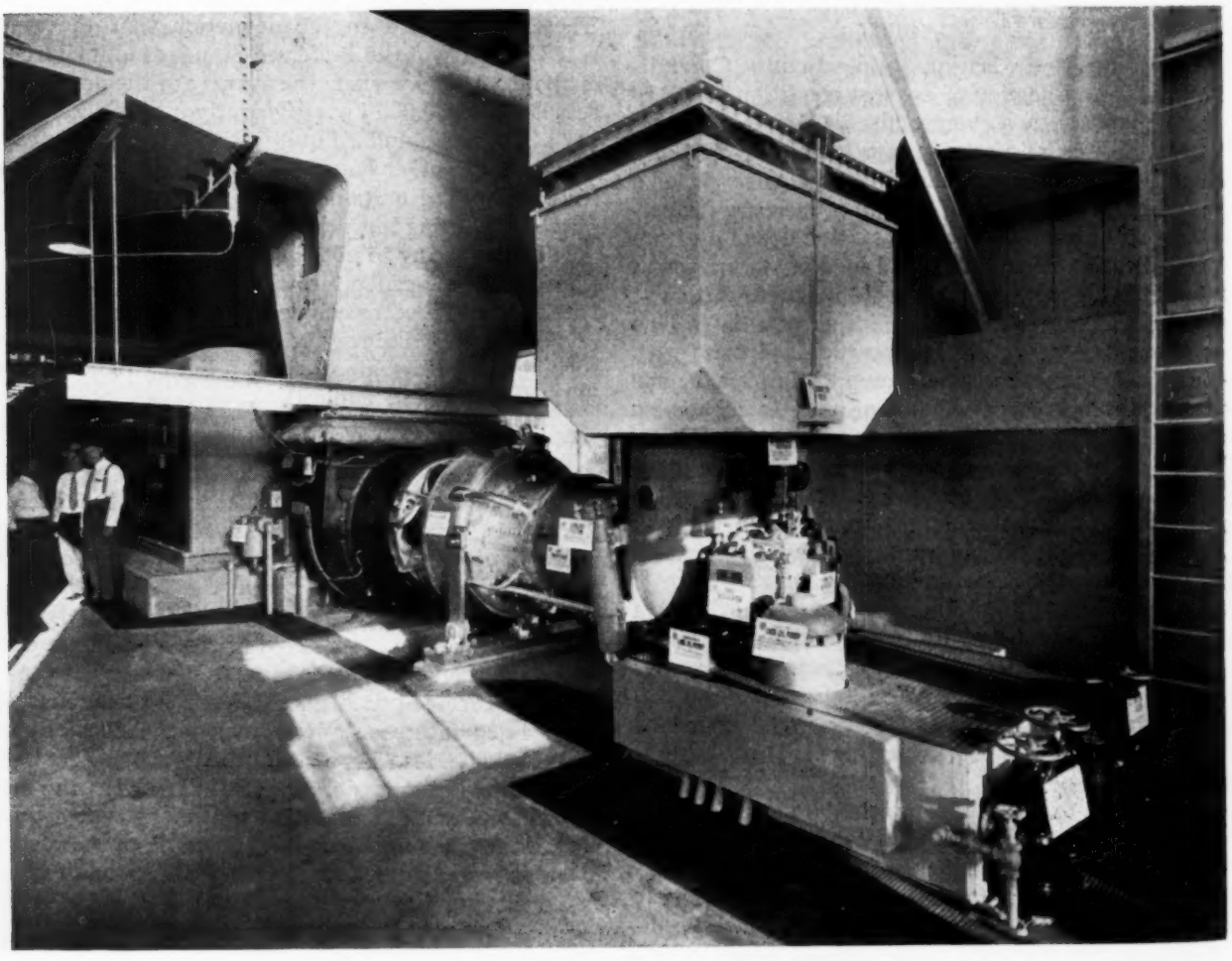
(*Continued on page 63*)

First Central Station Gas-Turbine Installation in U.S.

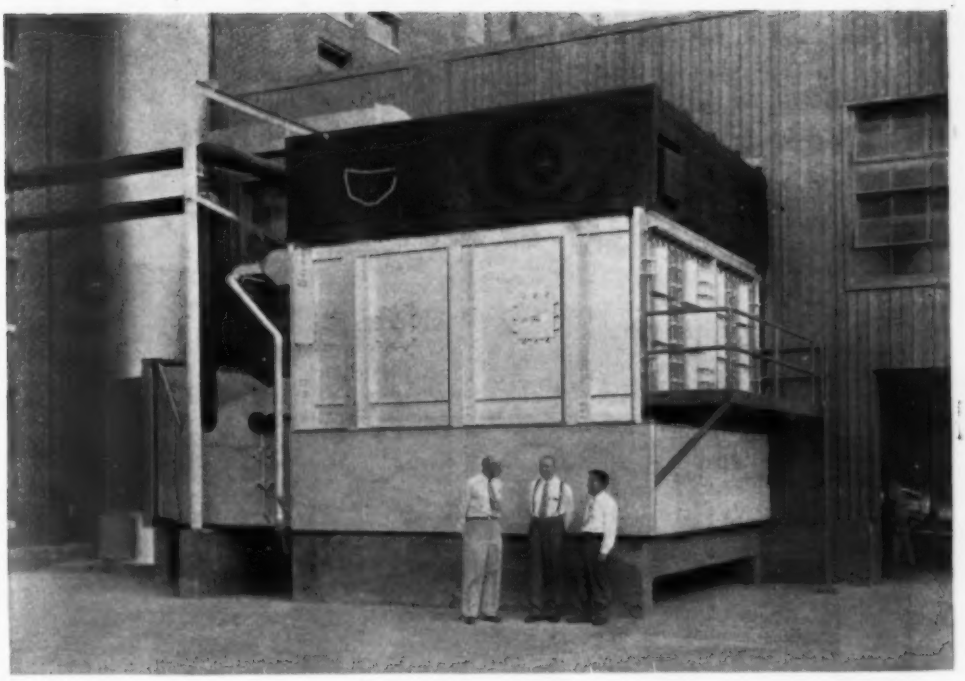
THE first public showing of a central station gas-turbine installation in this country was made during the A.S.M.E. Petroleum Division Meeting in Oklahoma City on October 3 when the group inspected the 3500-kw unit that forms an extension to the Arthur S. Huey Electric Generating Station of the Oklahoma Gas & Electric Company. This unit was first placed in service July 29, 1949, and up to the date of the inspection had operated 1078 hr with a total of 3,749,000 kwhr to its credit at an average load approximating its rated capacity.

The turbine, built by General Electric Company, is of the simple open-cycle type with two stages, is fired by natural gas and drives a 15-stage axial air compressor. The generator, with its exciter, is driven through a 6700–3600 rpm reduction gearing. The unit, including generator, exciter, and starting motor, occupies a space of less than 50 by 9 ft in a small building adjacent to the main power plant, and the total weight is only 25,000 lb thus simplifying the foundation problem. A feature of the installation is a recuperator placed between the turbine exhaust and the stack, which recovers heat from the exhaust gases to heat feedwater for the steam plant, thus raising the capability of the latter. This recuperator, supplied by Combustion Engineering-Superheater, Inc., is located adjacent to one side of the building housing the gas turbine, and at the far side is located the air cooler.

Huey Station, which first went into service in 1930 had a rated capacity of 51,000 kw in two units (one 31,000 kw and one 20,000 kw) prior to installation of the gas turbine. However, on September 28, according to C. C. Willis, superintendent of the Company's generating stations, the gas turbine permitted a pickup in total station output from approximately 51,000 kw to 58,000 kw, accompanied by an overall improvement in plant operating economy. Of this pickup the gas turbine accounted for around 4000 kw and the balance of 3000 kw was



The gas turbine unit occupies a space of 50 by 9 ft.



View of recuperator exhausting to stack; door to turbine room is seen at the right.

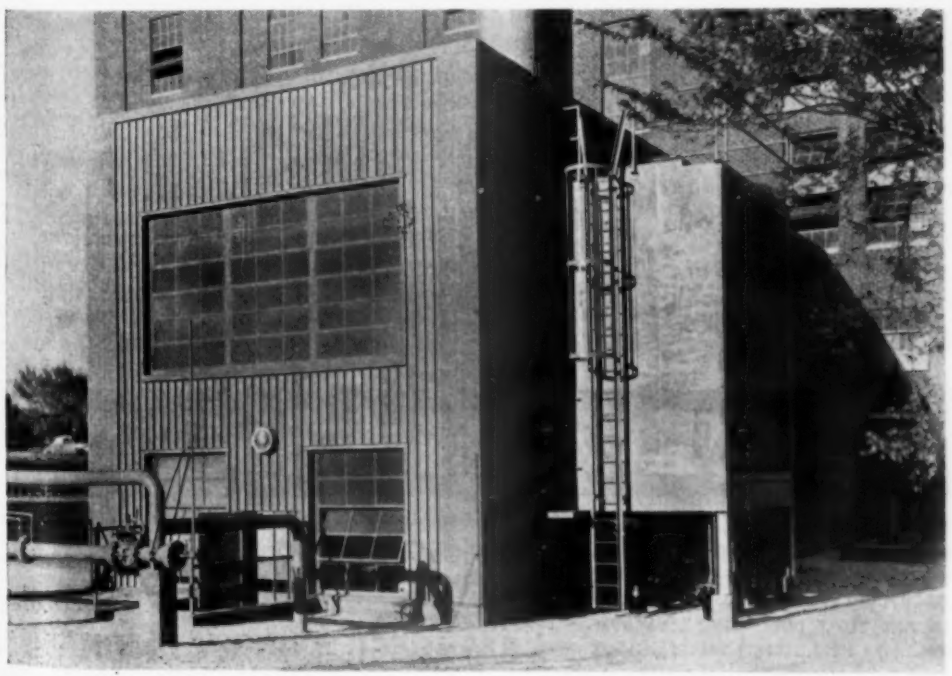
achieved in the steam plant, through recovery of heat from the turbine exhaust. The maximum load carried by the gas turbine unit has been 4300 kw. Installation costs were as follows:

Building, grounds and foundations	$ 79,851
Gas turbine unit erected	400,107
Automatic control	28,393
Recuperator erected	91,140
Stack and ductwork	32,548
Air intake cooler	9,237
Piping	51,225
Electrical	34,486
Miscellaneous	3,013
Total cost	$730,000

This figure represents approximately $208 per kilowatt of rated capacity of the gas turbine or $170 per kilowatt of its maximum capability without credit for the heat given up to the feedwater of the steam plant. The cost per kilowatt of combined increased capability, due to use of the recuperator, figures approximately $104.

Operating data, as of September 23, when a maximum load of 4300 kw was being carried, showed an average inlet air temperature of 71 F; an average turbine inlet temperature of 1290 F and exhaust of 780 F; flue gas to the stack 340 F; Btu per kwhr for the turbine unit only of 21,960; and Btu per kwhr for the combination with steam of 16,220 net.

Huey Station is second largest of the Company's five major power plants serving, through an interconnected transmission system, some 236 towns in Oklahoma and Western Arkansas.



Exterior view of extension housing the gas turbine set, with air cleaner and precooler shown at right.

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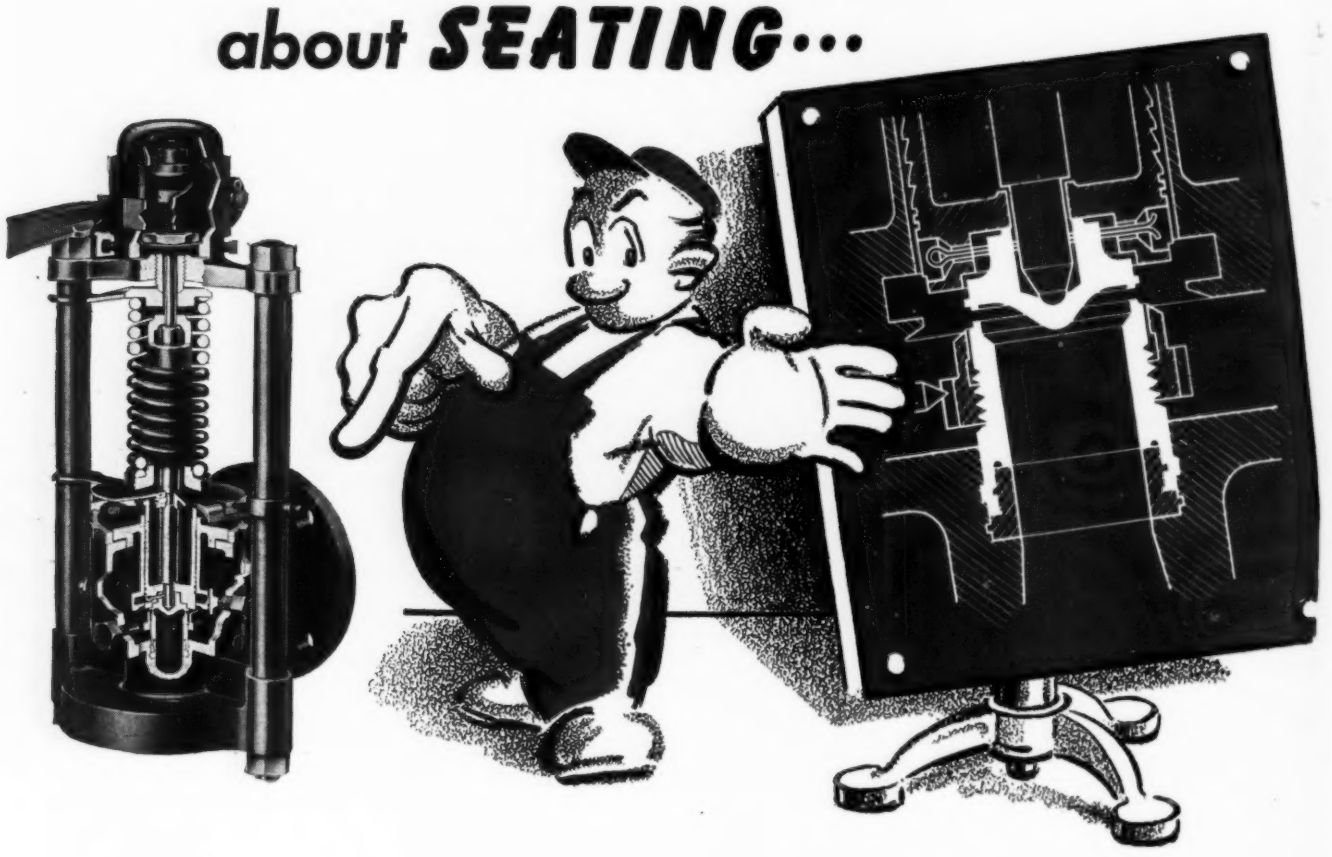

We found — what most power plant men already know...that in order to be tight, a safety valve must have matched, wear resistant, corrosion resistant seating surfaces, and that the disc must seat square.

We found — what power plant men have long suspected...that uneven expansion, causing dragging of one seating surface over the other, can destroy the seat so completely that the safety valve has to be overhauled or replaced, even though it has never been popped.

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Fly Ash From Stokers*

By

E. M. POWELL

Combustion Engineering-Superheater, Inc.

With stoker firing the most important items affecting cinder carryover are sizing and ash content of the coal, the firing rate and the quantity of cinders collected in the hoppers. Reinjection into the furnace for burning of cinders from the boiler hoppers only is compared with complete reinjection from the hoppers and dust collector.

THE three primary factors contributing to the rate of fly-ash erosion are the quantity of dust, the nature of that dust and the velocity of the dust particle. The effect that quantity has on the rate of erosion is well appreciated. Localized erosion which occurs where the dust has been concentrated in the gas stream by sharp changes of direction is a typical example. With pulverized-coal firing the rate of erosion has been found to be practically in direct proportion to the ash content in the coal fired. With the stoker firing, however, the rate of erosion is proportionate to the rate of cinder carryover from the stoker, which is not necessarily a function of the ash content in the coal.

Stoker Cinders More Abrasive

By the term "nature of dust" is meant the degree of abrasiveness. Cinders of high carbon content, such as stoker cinders, are generally accepted as being more abrasive than well burned-out ash from pulverized coal. The size of the dust has a further effect on its abrasiveness, or possibly the force with which it scrubs the tubes. This was recently demonstrated in the laboratory by Fisher and Davis.[1]

The effect of velocity on erosion was very thoroughly studied by Fisher and Davis[1] and by R. L. Stoker.[2] They demonstrated that the rate of erosion varied rapidly with velocity. Throughout the lower velocity range the relative erosion rate varied as the 2.5 power of velocity and increased to the 4.5 power as the velocity increased to 1000 ft per sec. Velocities normally employed in boilers are sufficiently low not alone to be a major factor in fly-ash erosion except as they contribute to the concentration of ash over localized zones, such as at the ends of baffles. High gas velocities usually mean baffles and comparatively high draft loss across the baffles. There have been instances where high draft loss and a baffle leak produced extremely high velocities that resulted in localized but serious erosion.

With pulverized coal firing the quantity of ash to be passed through the heat-transfer equipment is a definite quantity and a function of the ash content in the coal. The designer, or operator, has little control over that quantity. The only means at his disposal for avoiding excessive erosion is the type of boiler selected, which should be designed for low gas velocities and with an absence of sharp changes in direction. This problem has long been recognized and has been discussed at length in engineering literature.

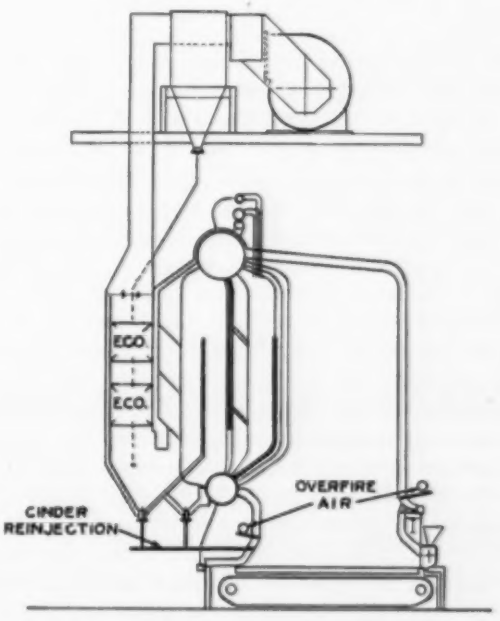

Fig. 1—Arrangement in Plant A

* A paper presented at the A.S.M.E. Fall Meeting at Erie, Pa., September 28-30, 1949.

[1] M. A. Fisher and E. F. Davis, "Studies on Fly Ash Erosion," presented before A.S.M.E., December 1948.

[2] R. L. Stoker, "Erosion Due to Dust Particles in a Gas Stream," *Industrial and Engineering Chemistry*, June 1949.

Spreader-Stoker Firing

With stoker firing, however, the problem is far different and more complex. Little factual information has so far been published. The most serious offender has been the spreader stoker, to which the remainder of this discussion will be directed. Important items contributing to cinder carryover with this type of firing are:

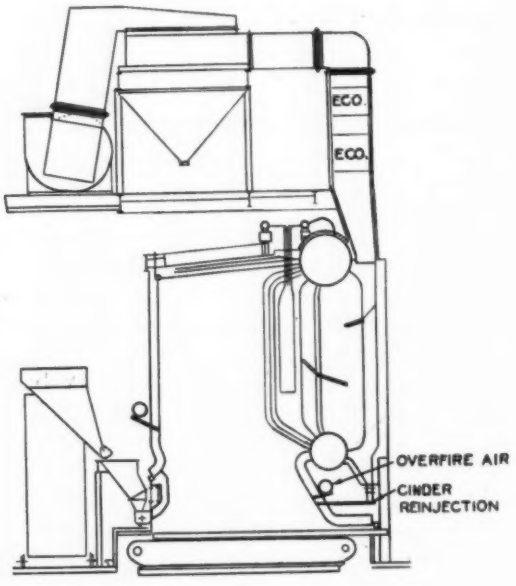

Fig. 2—Arrangement in Plant B

(1) sizing and ash content of the coal, (2) the firing rate, and (3) the amount of cinders collected in hoppers and returned to the furnace for the recovery of unburned carbon.

Tests were recently completed on two units fired with continuous discharge spreader stokers. Fig. 1 shows a unit installed in an Eastern industrial plant having a continuous capacity of 100,000 lb per hr, which will be designated as Plant A. It is fired with eastern bituminous coal having a size classification of $1^1/_4$-in. by 0. This stoker is 17 ft 9 in. long by 17 ft wide and is equipped with a reinjection system for returning the cinders collected in the boiler, economizer and dust collector hoppers through the rear wall of the furnace. It was so arranged that during the tests the cinders from the dust collectors could be separately weighed and reinjected into the furnace or thrown away. Provision was made for overfire turbulence by means of 30-in. air jets located immediately above the cinder-return nozzles. Two jets were also located in the front wall of the furnace. Tests were run at several ratings, both with and without cinder return from the dust collectors. Dust samples were taken in the gas duct between the economizer and dust collectors to determine the quantity, fineness and carbon content. The amount collected in the dust collector hoppers was also weighed. Other data necessary for determining the complete heat balance were collected.

The other unit, shown in Fig. 2 and installed in a midwestern industrial plant, has a continuous capacity of 150,000 lb per hr and is designated as Plant B. The stoker is 20 ft long by 22 ft wide and is fired with a midwestern bituminous coal having a size classification of $^3/_4$ in. by 0. This unit was arranged to reinject the ash from the boiler hopper *only* with no provision for returning the dust collector cinders to the furnace. Complete heat-balance data were collected in addition to dust samples at the induced-draft fan discharge, and the weight of cinders collected in the dust collector was determined. The overfire air system is very similar to that of the other unit, as is also the location of the reinjection nozzles.

Cinder carryover entering the dust collector for both units is plotted against firing rate in Fig. 3. For comparison the quantities have been expressed as pounds of dust per 1000 lb of gas, corresponding to 12 per cent CO_2. The abscissa is the stoker firing rate expressed as Btu per hr per sq ft of grate area.

The close agreement between these two units when not returning dust collector cinders is surprisingly good. The greater carryover which would normally be expected at Plant B, because of the somewhat finer coal sizing, apparently has been offset by the fact that Plant A returns cinders from two sets of hoppers instead of one. It will be noted that the firing rate has a very definite effect on cinder carryover. Without reinjection that rate varied as the cube of the rating. When returning cinders from the dust collector, the rate of carryover varied as the 3.5 power of the rating. Reliable data could not be obtained with reinjection beyond a firing rate of 400,000 Btu per hr per sq ft because of the extremely large quantities of dust to be handled.

Having measured the quantity and carbon content of the dust going to the dust collectors at Plant A, we calculated the ratio of cinders entering the dust collector with the reinjection of dust collector cinders to the quantity without reinjection. This was found to be $3^3/_4$ at a firing rate of 360,000 Btu per hr per sq ft. The dust

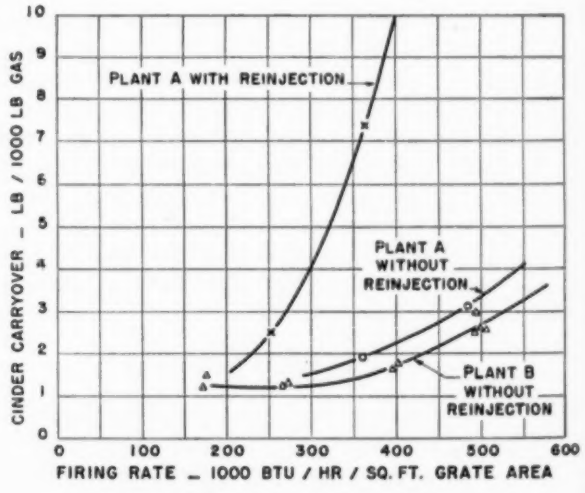

Fig. 3—Cinder carryover vs. firing rate

collector efficiency was calculated as 80 per cent and the fraction of carbon loss recovered by reinjection was 67 per cent, which represented a saving in efficiency of 0.9 per cent.

These calculations were based on two assumptions: first, that the same quantity of cinders will be carried over from the incoming fuel with and without reinjection; and second, that none of the ash returned to the furnace by reinjection will find its way to the ash pit. This is

not an unjustifiable assumption when it is considered that this type of stoker employs a thin fuel bed and the stoker grate travels at the rate of approximately ten feet per hour, meaning that it takes over $1\frac{1}{2}$ hr for dust deposited on the fuel bed at the rear of the stoker to travel to the

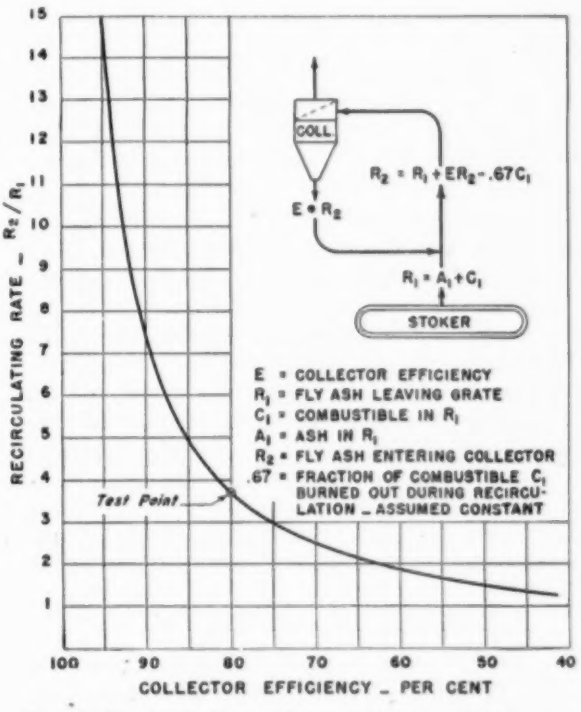
RECIRCULATING RATE — R_2/R_1
COLLECTOR EFFICIENCY — PER CENT
COLL
$R_2 = R_1 + ER_2 - .67C_1$
$E \cdot R_2$
$R_1 = A_1 + C_1$
STOKER
E = COLLECTOR EFFICIENCY
R_1 = FLY ASH LEAVING GRATE
C_1 = COMBUSTIBLE IN R_1
A_1 = ASH IN R_1
R_2 = FLY ASH ENTERING COLLECTOR
.67 = FRACTION OF COMBUSTIBLE C_1 BURNED OUT DURING RECIRCULATION — ASSUMED CONSTANT
Test Point

Fig. 4—Recirculation rate vs. collector efficiency

front of the furnace and be discharged into the ash pit. Cinders that have been lifted from the fuel bed and carried to the dust collector will, on being returned to the furnace and having some of the carbon removed, be somewhat finer. It cannot be expected that much of that material could be so placed on this thin fuel bed that it would not be lifted from it again by the air flow through the stoker.

Dust collectors are normally installed to avoid a nuisance. Where the dust is returned to the furnace, the nuisance to the immediate neighborhood is lessened to the extent that most of the carbon has been removed from the fly ash discharged from the stack, and the size of that ash has been considerably reduced. The primary function of the dust collector in this instance, however, is to vary the number of times the cinders will be passed through the furnace and the amount of carbon that can be recovered in the process. This is illustrated in Fig. 4. This shows the quantity of refuse entering the dust collector R_2, being equal to R_1 plus $E \times R_2$ minus 0.67 C_1; where R_1 represents the refuse carried over from the stoker, E the dust collector efficiency, 0.67 the fraction of the carbon carried over from the stoker which has been burned by reinjection and C_1 the quantity of carbon from the stoker. This analysis is based on the two assumptions outlined previously. It will be recalled that at Plant A a recirculating ratio of 3.75 was determined at a firing rate of 360,000 Btu per hr per sq ft, and the dust collector efficiency was found to be 80 per cent. If only the collector efficiency is varied, the recirculating ratio will vary as indicated by this curve. Increasing the efficiency from 80 to 90 per cent will double the quantity of cinders to be circulated through the boiler, and an increase from 80 to 95 per cent in efficiency will increase the dust loading of the gases four times.

An analysis of this equation will show that the quantity of dust leaving the stack will be equal to the cinder carryover from the stoker less the quantity of carbon burned by reinjection. The efficiency of the dust collector will not affect that quantity, excepting as it affects the carbon burned. There are a number of smoke ordinances in effect which limit dust emission to around one pound per 1000 lb of gas. To meet such an ordinance when returning cinders from the dust collector to the furnace would require limiting the firing rate on the stoker to something less than 300,000 Btu per hr per sq ft. In so far as firing conditions are concerned, 500,000 to 550,000 Btu per hr per sq ft is considered conservative. Such a limitation, therefore, cannot be economically justified.

The primary function of reinjection is, of course, the recovery of unburned carbon in the fly ash. Tests on both of these units indicate that if the combustion rate is limited to approximately 500,000 Btu per hr per sq ft, the total carbon loss in the cinders will be less than 2 per cent without reinjection. With reinjection approximately two thirds can be recovered. The cost of that increase in efficiency must be balanced against several factors, namely: (1) additional operating and maintenance costs required for the soot blowers; (2) increased maintenance from the erosion of boiler tubes; (3) increased maintenance of the furnace walls due to increased slagging; (4) reduction in heat-transfer efficiency due to greater ash accumulation on the heating surfaces; (5) increased maintenance of the induced-draft fan, fly-ash equipment, etc., because of the higher dust loading of the gases; and (6) the increased dust nuisance to the community.

It has not been the purpose of this discussion to condemn the practice of returning dust collector cinders to the furnace, but rather to present data which will help toward making a proper evaluation of some of the many factors involved in its use. Collecting accurate data of this type is tedious and exacting. Additional tests are desirable for a complete study of the problem. However, the trends and principles indicated by the data presented here are unmistakable.

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Tenth Annual Water Conference

Among the topics discussed were water-treatment problems experienced in starting a new central station, generation of pure steam at high pressure, selection of deaerating feedwater heaters, demineralization and ion-exchange water-treatment operating experiences, the use of resinous zeolites on the hydrogen cycle, and a new anti-corrosion agent for power-plant return lines. This account includes abstracts of the principal papers and a partial report on the discussion.

AT THE Tenth Annual Water Conference sponsored by the Engineers' Society of Western Pennsylvania and held at the William Penn Hotel in Pittsburgh, Penna., on October 17–19 there were a number of papers of interest to engineers in the steam power field.[1]

Opening remarks were delivered by **S. F. Whirl,** general chairman of the conference, who offered a brief memorial to the late H. M. Olson, for many years chairman of the Water Conference and one of those largely responsible for its present growth. Then **W. C. Schroeder** gave a short report on the activities of the Joint Research Committee on Boiler Feedwater Studies. At the present time this committee is acting as co-sponsor of a number of meetings in collaboration with leading technical societies and is coordinating some research activities relating to water treatment. Its three active subcommittees are studying deposits, corrosion and steam contamination.

Water Problems in Starting Mitchell Power Plant

W. L. Thompson, chemist of the West Penn Power Co., presented a paper on "Water Problems in the Starting of the Mitchell Power Plant of the West Penn Power Company." The first unit of this plant, which is located about 20 miles south of Pittsburgh, on the Monongahela River, was started in December 1948. There were three sources of water, namely, wells, the river, and treated city water. The first was limited in amount, and a comparison of the latter two indicated that it was economically advantageous to construct a filter plant to use the river water.

Precipitators and ion-exchange softeners were installed along with a mixing room and water-storage tanks. The river water has high turbidity, and at times of low flow when its acidity rises, lime is added to the regular treatment. Chlorine is introduced at three points: in the precipitator influent, after the filter and in the softener effluent. The operation of the pressure filters is fully automatic and has proved satisfactory to date.

The water-treatment plant was placed in service early in November 1948, manual control being used at the outset. The calcium hardness of the river water was found to be reduced from 35 ppm to 0.5 ppm or less.

Since neither distilled water nor condensate was available, it was necessary to boil out the first boiler with filtered water. In this process sodium triphosphate and sodium hydroxide were added to the boiler drum, and 56 blowdowns were made during the first 33 hours of the boiling-out period. For starting-up, the boiler was filled with softened water and brought up to rating over a period of nine days. Similar procedures were followed with the second boiler, except that the time was reduced because of the availability of additional control equipment. No evidence of grease was found after boiling out either of the two 1250-psig, 950-F boilers.

Discussion

The author was complimented for an unusually detailed record of starting-up problems encountered in central station water treatment. Mention was made that mill scale and iron oxide are not removed by the standard boiling-out procedure, and the question was raised as to what happens to the boiler during the period between the time of the first hydrostatic test and the actual boiling-out process. When this period extends over several months it was stated that an acid wash is preferred (by at least one boiler manufacturer). It was also suggested that protective coatings similar to those employed by the Navy in laying up ships might be considered; also, an internal protective coating for tubes, which has the properties of not being water soluble and unaffected by the hydrostatic test but capable of being removed during the boiling-out process. The use of tannin in the water for the hydrostatic test was likewise mentioned as being satisfactory for protection during the period under discussion, along with which it was recommended that the boiler drums be dried with air from fans. The importance of investigating metal surfaces to determine the presence of organic deposits was noted.

Several discussers spoke of methods used to obtain distilled water for starting up boilers in a new central station. In one case condensate was brought in by tank truck from another station, while in a second, it was reported that a locomotive was used to provide steam to the station evaporator before starting up. As to starting up boilers without complete instrumentation and controls, there were a number of comments regarding difficulties encountered when automatic instruments are not ready for operation. The demands to get a unit "on the line" may have serious consequences, and it was urged that work on centralized control be scheduled to coordinate with the start-up of major equipment.

[1] Copies of the complete papers and discussions may be obtained for $7.50 by writing to the society office at the same hotel.

Pure Steam at High Pressures

In a paper entitled "The Problem of Generating Pure Steam at High Pressures" by **Martin Frisch** and **R. A. Lorenzini** of the Foster Wheeler Corp. the authors pointed out that the demands for pure steam from high-pressure boilers are becoming more and more stringent and that turbine blade fouling may occur with steam containing less than one part per million total solids. They went on to say:

"Complete elimination of superheater and turbine deposits resolves into the elimination of (1) mechanically entrained moisture carrying dissolved chemicals, (2) mechanically suspended fine particles of solid matter, (3) vapors which may condense as solids where they can do harm and (4) compounds dissolved in the steam which may crystallize out."

Correlation of the design of the steam purification system and the boiler circulating system is necessary to produce steam of acceptable purity. To maintain the circulation rate at a maximum and to reduce gage-glass error to a minimum, steam-free water is necessary, while water-free steam is essential for perfect steam purity.

Motion pictures and slides were presented to illustrate internal conditions in the drum which are causes of gage-glass error. The authors emphasized the importance of locating water connections close to the desired normal level in order to avoid swamping the drum at high gage-glass levels and indicated that intolerable drum swell is inevitable if the gage is too long and the drum water is not effectively de-steamed. Since high drum levels and carryover go together it is important to reduce the difference between the true drum level and the gage-glass level.

Circulation Studies

Even small amounts of steam in circulating water may have an appreciable effect upon circulation below 1500 psi. Studies were undertaken on three twin-furnace boiler installations to determine correlations between effectiveness of de-steaming, circulation, drum level and steam purity. The determinations demonstrated that the water level may be carried lower with better de-steaming before impairing circulation and higher before increasing carryover because of reduced gage-glass error.

Professor F. G. Straub has shown that silica passes into steam in vaporized form and that the amounts passing over increase with the increase in temperature and the concentration of the silica in the water in contact with the steam where it is disengaged. On this basis the authors felt that it would appear logical that in a steam washer the equilibrium between the concentration of the impurity in the vapor and contacting liquid would depend on the properties of the wash water rather than on those of the boiler water.

Mention was made of the dual-circulation boiler consisting of two separate heat-absorbing sections, each with its own independent circulation system. The principal advantage claimed for this arrangement is a reduction in the amount of silica contamination of steam because a large proportion of the steam is made in the section of the boiler having the lowest concentration.

In concluding, the authors further emphasized the importance of minimizing gage-glass errors, recommended that at very high pressures, solutes which are vaporized or dissolved in the steam be removed by a washer-drier combination, and expressed the opinion that, where either condensate or high make-up is used as feedwater, the dual-circulation boiler shows promise of producing steam of higher purity than that attainable in conventional boilers.

Discussion

The need for a reliable and rapid method for the determination of very small amounts of silica was pointed out by **E. Pirsh** of Babcock & Wilcox, who called attention to silica-deposit studies now being made by the Armour Research Foundation. Not all of the fundamentals of silica deposits on turbine blades are known, and ways and means must be found to reduce silica carryover to sufficiently low values so that deposition is negligible.

B. J. Cross of Combustion Engineering-Superheater, Inc., noted that boiler drums serve at least four functions, of which three relate to steam purification. These include primary separation, steam washing and final drying, and in addition the drum acts as a water reservoir. Some of the considerations in determining a compromise value for design operating level in the drum are these: (1) water reserve necessary for practical operation; (2) the level necessary to insure an adequate separation of steam from the water to the downcomer circuits; (3) the space requirements for equilibrium conditions between steam and feedwater; and (4) the space necessary for separation of feedwater from steam after the washing process. Mr. Cross referred to a boiler designed for high superheat and reheat and having two drums set at the same level. In this design all of the steam is generated in the furnace tubes, from where it discharges into one drum in which bulk steam-water separation takes place. The steam then passes to the second drum for the completion of the washing process. The advantages of this arrangement are the larger space provided for both separation of steam and water storage, and the reduced effect of boiler water concentration and of circulation ratio.

In his closure Mr. Frisch signified agreement with the need for a quick method of determining small amounts of silica in water. He observed that the boiler drum has become a purifying plant and that a better job could be done if the economics of competition permitted more drums and more steam space. It was agreed that the scheme of having two upper drums set at the same level had merit.

Deaerating Feedwater Heaters

The first of two papers on deaerating feedwater heaters was delivered by **E. B. Kuhn** of the Elliott Company under the title, "Deaerating Feedwater Heater Problems." The subject was approached from the point of view of an engineer who follows the details of a power plant from the time of its inception through the stages of initial operation. In the selection of deaerating feedwater equipment consideration should be given to required maximum capacities and to the amount of storage that may be desired. Likewise,

the degree of oxygen removal must be decided upon, keeping in mind the amount of protection against oxygen corrosion that may be justified. In proceeding with the plant layout either a horizontal or vertical deaerating heater may be selected, depending upon available space and the amount of required storage.

The author discussed steps that should be followed in installing and starting up deaerating equipment. Among operating problems he noted that such heaters are not generally fitted with vacuum equipment for subatmospheric operation, a problem frequently encountered when exhaust steam from turbine drives is used. In these instances some means should be made to supply additional steam from other sources, possibly through a pressure-reducing valve from the main steam header. For central stations this problem may be solved by providing vacuum equipment in conjunction with an automatic control valve or by the use of a pressure-reducing valve to supply steam from the next higher bleed pressure.

Water hammer is another common operating problem which is troublesome, although water seals are helpful. Piping arrangements from the deaerating feedwater heater to the boiler-feed pumps may be a source of operating difficulties, particularly when station load is being dropped and energy stored in the water in the storage space is released in the form of flashed steam. The latter may be entrained in the water going to the boiler-feed pumps, causing the pump to become vapor bound. The speaker observed that inlet control valves are most commonly oversized, a condition which results in poor regulation, chattering, and generally poor service.

In concluding Mr. Kuhn listed the following as the main points of maintenance for deaerating feedwater heaters: vent condenser tubes, inlet control valves and controllers, overflow control valves and controllers, trays, and heating and deaerating spray valves.

"Deaerating Heaters—Spray Type Vs. Tray Type" by **A. L. Jones** of Worthington Pump & Machinery Corp. was the title of the second paper in this series. The spray type or steam-jet deaerator has had its major development in the marine field, but it is coming into increasing use in stationary power plants. During World War II steam jet deaerators aboard vessels performed under adverse conditions and gave excellent service.

For thorough deaeration Mr. Jones stated that (1) the water must be heated to steam temperature; (2) the water must be scrubbed by passing steam through it or about it to reduce the partial pressure around the water and permit the rapid escape of entrained oxygen; and (3) the liberated oxygen must be removed from the immediate proximity of the water by adequate venting. In the tray-type deaerator, trays or baffles are employed to spread the water in thin sheets, fine streams or small drops in the heating and deaerating sections. In the steam-jet deaerator the heating section is composed of a multiplicity of small spring-loaded spray valves and the necessary baffles for directing the heated water into the deaerating section. This section is where incoming steam is passed through the already heated and partially deaerated water and may be a spring- or weight-loaded atomizer or a chamber in which the steam and water are mixed, compressed and released.

In conclusion Mr. Jones urged that the user weigh the advantages and disadvantages of each type for his particular application before making a definite choice. With the exception of a plant having an excess of exhaust steam the purchaser cannot go far wrong in choosing either type.

Discussion

Comparison of the two types of deaerating feedwater heaters evoked some heated discussion on the relative merits of each. There was a particularly spirited defense of the tray-type deaerating feedwater heater, and mention was made of the so-called jet tray deaerator which combines features of both types.

In connection with operating problems, the matter of the internal condition of the heater between the time of its manufacture and its being placed in service was brought up. Some builders apply internal coating, although this may not be necessary if the unit is properly dried and prepared for shipping. One objection to the use of internal protective coatings is their effect upon deaerator start-up operation, for it may be months until a proper oxygen test can be made. Other suggested means of protection included the use of desiccating agents and vapor-phase inhibitors.

Ion-Exchange Plant Operations

Two papers were delivered on plant operating experiences with ion-exchange water treatment. The first of these, "Demineralization Operations at the Dow Chemical Company," was by **Louis Wirth, Jr.**, of the power division of that company. Beginning with an operating description of the 1500-gpm demineralization plant at Midland, Mich., the speaker outlined the control system, regenerating procedures, operating results, and revisions for an expansion of water-treatment facilities, based upon present experiences.

The Midland water-treatment plant is operated on the header system. All cation units function as a group discharging into a common header which, in turn, feeds a header common to the anion units. The discharge from the latter is fed directly to the deaerator, the effluent of which is pumped to the power plant. The four cation exchangers and five anion exchangers are similar in design except for the material of the underdrains and the addition of acid laterals to the cation exchangers. To maintain a flow rate of 1500 gpm the cation exchangers are designed for an individual flow rate of 5 gpm per sq ft of surface, three units being operated while the fourth is off the line for regeneration.

There is an extensive central control system which is housed in a separate room having approximately 40 ft of instrument panel. The service panel meters the raw water to the plant and the anion effluent to the deaerator. The unit operation and regeneration panel is divided into two parts, one of which contains the individual cation unit flow meters and operating controls, and the other, the individual anion unit flow meters and the devices necessary for the semi-automatic

regeneration of these units. To guard against failure of controls during regeneration, the regeneration-control electrical system is arranged in duplicate.

The cation resin employed is of the phenol formaldehyde type, in ground form. An aminated phenol formaldehyde resin was selected as the anion resin because preliminary research disclosed its ability to deliver water low in bicarbonate.

For a typical day's run, operating results show that silica is consistently less than 0.5 ppm, and for more than 50 per cent of the time it is less than 0.1 ppm. This water is supplied to a 1250-psig boiler operating with 100 per cent makeup. It is estimated that water costs, including chemicals, wash water, and the cost of the water being processed, are on the order of 27 cents per thousand gallons, but it is expected that improvements in operation will effect a reduction in these costs. The cost of equipment for the continuous demineralizing operating capacity of 3000 gpm is estimated to be just in excess of $720,000.

The present 1500-gpm plant is to be expanded to 3000 gpm, and in the new section removal of silica will be accomplished without the use of a fluoride and the deaerator will be located between the cation and anion exchangers. The anion resin will be caustic soda regenerated, with the regeneration control incorporated into existing equipment. The completed project will allow for a blending of the two finished demineralized waters which will be ideally suited as the water from the newly installed unit will contain no CO_2, thus giving better quality total water from the plant as a whole.

The second paper on ion-exchange plant operations was delivered by **A. R. Pettyjohn** of the Carbide and Carbon Chemicals Corp. and was entitled "Operations of the Ion Exchange Water Treating Plant at Texas City." Experiences were described using the controlled cation exchange of shallow well water, the demineralization of a more highly mineralized deeper well water, and the straight softening of clarified, filtered river water, cation-exchange material being employed in the sodium cycle in the last case. Mr. Pettyjohn discussed the reasons for the selection of the different methods of water treatment, the regeneration chemical requirements, and some of the operating results and difficulties encountered.

Two cation-exchange units were installed in 1941 and a third was added in 1943, all being used to treat the shallow well water. The latter contained 950 ppm dissolved solids comprised principally of 390 ppm total alkalinity, 180 ppm chloride, 20 ppm hardness and 20 ppm dissolved silica. The use of controlled cation-exchange material, operating in both the hydrogen and sodium cycles, offered the ideal solution, for the hardness could be reduced to a minimum and the excess of bicarbonate could be eliminated to form carbonic acid, thus not only reducing the original alkalinity but also lowering the dissolved solids.

Water treated in the original cation-exchange units contained approximately 425 ppm dissolved solids composed of 60–65 ppm of alkalinity, less than 1 ppm total hardness, and the original amount of dissolved silica and chloride.

In regeneration great importance was attached to correct and adequate backwashing. It was found that the beds were neither completely regenerated at the start of the run, nor were they completely exhausted at the end of the treating run.

When the third unit was installed in 1943 it was discovered that there had been a marked drop in the groundwater table. Expansion of the entire plant was planned in 1945, and it became necessary to resort to deeper wells whose water contained 1900–2000 ppm dissolved solids, including 290 ppm alkalinity, 800 ppm chloride, 120 ppm hardness and 30 ppm dissolved silica.

The treatment of deep-well water in controlled-exchange units was not practicable because the lower alkalinity of this water would not provide sufficient reduction of total solids. Demineralization of this deep-well water appeared to be satisfactory as a stop-gap method. The flow of the deep-well water during this process is through a cation-exchange bed, an anion-exchange bed, over a forced-draft wood-slat degasifier and to storage tanks. While little experimentation was undertaken on the demineralization units, this method of treatment reduced the total dissolved solids of the deep-well water from nearly 2000 ppm to about 100 ppm, including the unaffected 30 ppm of silica.

In 1948 river water was made available, and it was passed through a clarification plant and, for a short period, through the demineralization units as well. The latter reduced dissolved solids from 450 ppm to 60–70 ppm. As the reliability of the river-water supply became more certain some of the cation-exchange units were converted for use as sodium-cycle softeners, and to date operation has been satisfactory.

Mr. Pettyjohn concluded by affirming that the use of ion-exchange materials has led to favorable regard for them in the treatment of boiler feedwater. Problems thus far faced have been mainly mechanical in nature.

Discussion

Much of the discussion of the two preceding papers centered about the amount of automatic control that can be justified in the operation of ion-exchange water-treatment plants. The Dow Chemical Company Midland plant is almost completely automatic, while operation at the Carbide & Carbon Chemicals Corp. Texas City plant is by manual control. A difference of opinion existed as to the consistent quality of treated water obtainable without automatic control, and the relative labor saving with fully automatic operation was questioned. Several discussers reiterated the critical importance of uniform backwash, and there appeared to be general agreement concerning the success of the demineralizing and ion-exchange treatment for preparing boiler feedwater from sources having high mineral content.

Resin Zeolites

A paper on "Operating Experience with Resin Zeolites on the Hydrogen Cycle" was presented by **V. J. Calise,** technical director of the Graver Water Conditioning Co. By comparison with information available on the performance of organic zeolites in the

sodium cycle with brine regeneration, few data have been published on the characteristics of organic zeolites in the hydrogen cycle with acid regeneration. The speaker presented operating data based on several commercial installations employing acid-regenerated resin zeolites and made comparisons with sulfonated coal zeolites.

The term "zeolite" is obtaining greater acceptance as a designation embracing all types of cation exchangers, whether they operate on the sodium or hydrogen cycles. Cation exchangers which are acid-resistant and subject to acid regeneration fall into two classes:

1. Those manufactured by treating coal with sulfuric acid and known as sulfonated coal-type zeolites.
2. Those manufactured from such organic chemicals as phenol, styrene or carboxylating compounds and known as resin-type zeolites.

There are two main applications for acid regenerated zeolites. One is alkalinity, hardness and solids reduction for boiler feedwater treatment in which the effluent from the hydrogen zeolite is passed through a degasifier to remove the free carbon dioxide and is then blended with a stream of soft sodium zeolite effluent, or with alkali, to produce a uniform methyl orange alkalinity in the mixed effluent. For use in high-pressure boiler plants as makeup this treated water must contain minimum quantities of hardness (sometimes less than 0.5 ppm) and alkalinity. The second application is as the first step in two-step or three-step demineralizing and silica removal, where it is necessary for the hydrogen zeolite to remove all the metallic cations from the raw water. The acid effluent usually flows into a weakly basic anion exchanger where all strong acids are removed and then degasified to remove free carbon dioxide. Where silica reduction is desired, this effluent can be passed through a strongly basic exchanger for silica removal by direct anion exchange.

Practical experience substantiated by laboratory and pilot plant tests has shown that cations which "leak" through both resin and sulfonated coal zeolites on the hydrogen cycle are sodium with no measureable traces of hardness as indicated by calcium or magnesium. Results from three commercial installations employing resin zeolites for feedwater treatment or demineralization were cited to show economical sulfuric acid dosages and marked reduction in dissolved solids. Experience has shown that effluent quality is influenced by depth of resin bed, regenerating technique employed, amount of acid regenerant, particle size of resin and operating flow rate.

Either hydrochloric or sulfuric acid may be used as a regenerant, but economics of today favor the latter, notwithstanding the slightly greater efficiency of hydrochloric acid. Once the type of acid and the amount of acid per cubic foot is fixed the concentration at which the regenerating acid solution comes into contact with the zeolite bed and the time of contact between regenerant and zeolite are important factors. They determine the degree of regeneration and influence the capacity and quality of effluent obtained.

Present evidence with operation of resin zeolites indicates that these materials have long life when installed and operated under proper conditions. Phenolic base materials will successfully withstand low and high pH, high temperature, attack by algae, fouling with growths, iron or calcium deposits, and attrition due to repeated backwashing, but they are affected by free residual chlorine concentrations in excess of 0.8 ppm. For the latter condition a non-phenolic base resin zeolite will be found resistant to high chlorine, temperature and high pH.

If acid-regenerated zeolite units are properly constructed of corrosion-resistant materials, long equipment life with minimum replacement is assured. Some hydrogen zeolite and demineralizing units have been in service for almost ten years, indicating that with properly constructed and well-designed equipment which is operated in accordance with instructions there need be little replacement or maintenance.

Discussion

In the discussion of Mr. Calise's paper it was brought out that water of excellent quality may be obtained by the use of resinous zeolites. Water composition has an important effect upon the type of cation exchanger to be used, since optimum results with one exchanger may be followed by very poor results with a second exchanger. The matter of relative capacities of resins and sulfonated coal was questioned on the basis that special regenerating materials may be required for resins. Mr. Calise summed up the discussion by pointing out that each material has specific properties from which the designer may obtain the best results.

Film Treatment for Corrosion

Announcement of a "New Polar Film Treatment for the Control of Return Line Corrosion" was made in a paper by **H. Lewis Kahler** and **J. K. Brown** of the W. H. & L. D. Betz Co. Carbon dioxide has been an important factor in return condensate line corrosion, although sulfur dioxide, hydrogen sulfide, and ammonia have also played a part in this condition. To offset the acidic effect of carbon dioxide, materials alkaline in nature have been used, among which the best known are amine compounds which have been employed since 1938, particularly in situations where their cost is not prohibitive.

The new treatment is octadecylamine and is called "Permacol." Its action involves deposit of a non-wettable film on the inside surfaces of pipe and fittings. This substance is said to deposit on corroded metal surfaces as well; it is not toxic in concentrations 100 times as great as its normal dosage of 30 ppm and does not affect the chemical characteristics of the water. Following extensive laboratory tests, commercial applications of this film-type amine were made in more than 50 plants, from which data are available covering nearly three years. The following figures provide comparative costs of two neutralizing amines, such as have long been used in return-line corrosion treatment, and the filming-type amine, "Permacol":

Substance	Cost per Lb	Solution	Dollars per Million Lb Steam	pH
Cyclohexylamine*	$0.45	60%	$54.00	7.0
Morpholine*	$0.50	91%	$32.00	7.0
Permacol*	$0.21	...	$ 6.30	Not affected

* Based on 40 ppm CO_2 and no recycling.

The authors stated that "Permacol" had been proved in plant operation to provide a desirable film that offers complete protection against attack by carbon dioxide, small concentrations of oxygen and other corrosive agents. The cost of this film-forming amine is much lower than for neutralizing-type amines offering the same degree of protection.

Discussion

That the use of filming substances to prevent corrosion is not new was brought out at the start of the discussion. Localized corrosion of a serious nature may occur where the film does not cover the surface, and the effects of turbulent flow were mentioned as possibly destructive of the film. It was asked whether a continuous film could be had without introducing new operating problems and whether the substance would have a marked effect upon heat transfer.

In closing Dr. Kahler stated that "Permacol" has some anti-foaming properties and that to date there has been no evidence of adverse effect upon boiler operations, such as sludging or sliming. Although it is an adsorption or blanket-type treatment, there has been no indication that "Permacol" affects heat transfer coefficients, nor has there been any chemical breakdown of the substance. In regard to the economics cited for the use of corrosion inhibitors, it was pointed out that both the neutralizing amines and the filming amines have a place in return-line treatment.

Insulation of Pipe Supports

To prevent excessive heat losses due to direct metal-to-metal contact between hot pipe surfaces and structural supports, insulated supports, so-called, may be used. In this type of installation, developed by Sargent & Lundy, Chicago engineers, from test work done at the University of Illinois, the entire length of piping is insulated in the usual manner and then supported by hangers or by channel irons.

Where the piping is to be supported by a hanger, a No. 10 gage steel plate, its length proportioned to the load to be carried, is rolled into a band to fit the insulated pipe and provided with a flange for assembly. A saddle plate, $^3/_8$ in. thick, is then tack welded around the lower half of the flanged band, to assist in carrying the direct load and in spreading it over a wide area. The unit is then bolted in place around the insulated pipe, a filler bar is fitted over the upper half of the flanged band, and the usual hanger strap is fastened around the entire assembly.

Where the pipe line is to be supported by channel irons, a 16-gage sheet metal band, 18 in. long and flanged for assembly, is bolted around the insulated pipe at each point of support.

Since the pipe rests on the insulation at the supports, the insulating material used must be able to bear the weight of the pipe. On the basis of the tests conducted at the University of Illinois, a loading capacity of 10 lb per sq in., or 100 lb per running in. of line, has been established for 85 per cent Magnesia.

Facts and Figures

Next to the railroads, electric utilities are the largest users of bituminous coal.

•

The energy per unit of weight with nuclear fuel is estimated to be about three million times that of coal.

•

The ratio of maximum steam requirements to turbine rating decreases as the size of unit increases.

•

Commercial refractories, with few exceptions, are oxides or combinations of oxides of chemical elements.

•

The resistance to corrosion from flue gas vapors of 18–8 alloy steel is said to be excellent up to about 18 months' exposure.

•

A coating of soot on boiler tubes $^1/_{32}$ in. thick is calculated to cause a loss in effective heat transfer of approximately 16 per cent.

•

Low stacks do not afford as great a dispersion of sulfur fumes as do high stacks. This is important when burning certain midwestern coals.

•

In drying coal that has been washed it is advisable to remove as much moisture as possible by mechanical means ahead of the drying operation by heat.

•

The coal strike of 1946 is reported to have cost each miner $650 which, at the new rate then won, would have taken till April 1953 to recover, had not further stoppages intervened.

•

The new Pyrmont B. Station now under construction near Sydney, Australia, is designed for an ultimate capacity of 200,000 kw in four 50,000-kw units, each supplied with steam at 1250 psi, 950 F, by a 430,000-lb per hr boiler.

•

According to the U. S. Bureau of Mines, the marketed production of natural gas in the United States during 1948 amounted to more than five trillion cubic feet and the consumption is still increasing.

•

Sulfuric acid regeneration has a lower efficiency than hydrochloric acid regeneration in zeolite treatment of water containing substantial amounts of calcium ion.

•

At currently high initial steam temperatures there is a gain of 1 to $1^1/_3$ per cent in turbine heat rate for each 50 deg increase in temperature.

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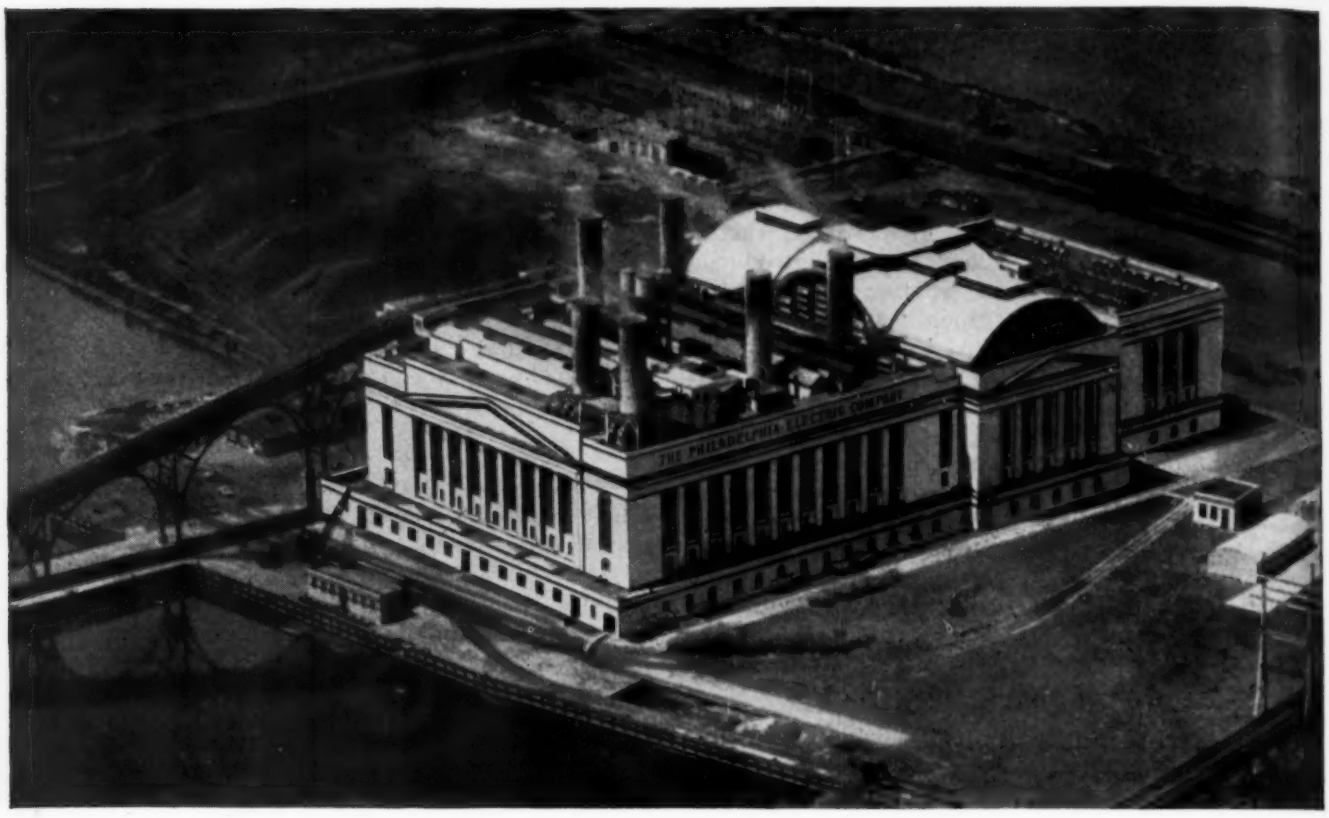

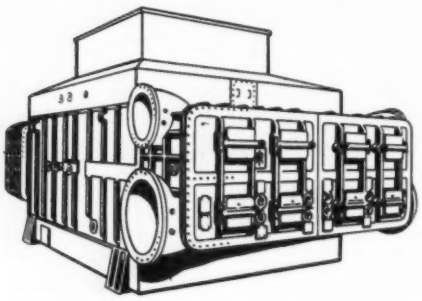

Ingersoll-Rand rectangular condensers are saving space and construction costs in many new generating units and those now under construction.

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I-R Condenser will serve new 165,000 kw generator at Richmond Station

The Richmond Station of the Philadelphia Electric Co. serves fast-growing Northeastern Philadelphia. Industrial expansion in this area plus careful planning for future needs has resulted in the addition of this new 165,000 kw generating unit. An Ingersoll-Rand 75,000 sq ft single-pass Rectangular Condenser with two I-R 70,000 gpm vertical circulating water pumps will serve the 1800 rpm, 13,800 volt tandem-compound turbo-generator. Steam operating conditions will be 1250 psig, 950° F.

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Some Pertinent Power Figures

A review of recent reports issued by the Federal Power Commission shows the combined installed capacity of utility and industrial power plants in the United States to be over 73 million kilowatts, of which utility plants, private and public, account for 60 million. Steam represents nearly 70 per cent of the utility capacity. Output has doubled in the last 8 yr; but, despite increased output, coal consumption during the current year has decreased, accompanied by greatly increased consumption of oil and gas.

THE relative positions of private and publicly owned electric utility power plants in the United States and the sources of energy supply are revealed by a study of several reports recently issued by the Federal Power Commission, some of the data carrying through December 31, 1948, and some through August 31, 1949. Both capacity and output are recorded and figures are given on power generated by private industrial power plants.

Considering first the situation at the beginning of the current year, there was listed a total of 3879 private and publicly owned utility plants with a combined installed capacity of 56,560,000 kw, of which 39,304,000 kw was steam, 15,652,000 kw hydro, and 1,604,000 kw internal combustion engines. In other words, steam accounted for 69.5 per cent of the total capacity, hydro 27.7 per cent, and 2.8 per cent internal-combustion engines. Of the total output for the year (282,698,214,000 kwhr), 69.8 per cent was produced by steam plants, 29.4 per cent by hydro and 0.8 by internal-combustion engines.

As to ownership, approximately 61 per cent of the plants were privately owned and 39 per cent publicly owned, the latter including federal, state, municipal and cooperatives. Private utility ownership accounted for 707 steam plants of 35,791,000 kw combined capacity, and public ownership for 342 steam plants of 3,513,000 kw; whereas 1124 hydro plants of 9,028,000 kw were privately owned and 343 hydro plants aggregating 6,624,000 kw were publicly owned. Of the 1367 internal-combustion engine plants, 549 were privately owned and 818 publicly owned.

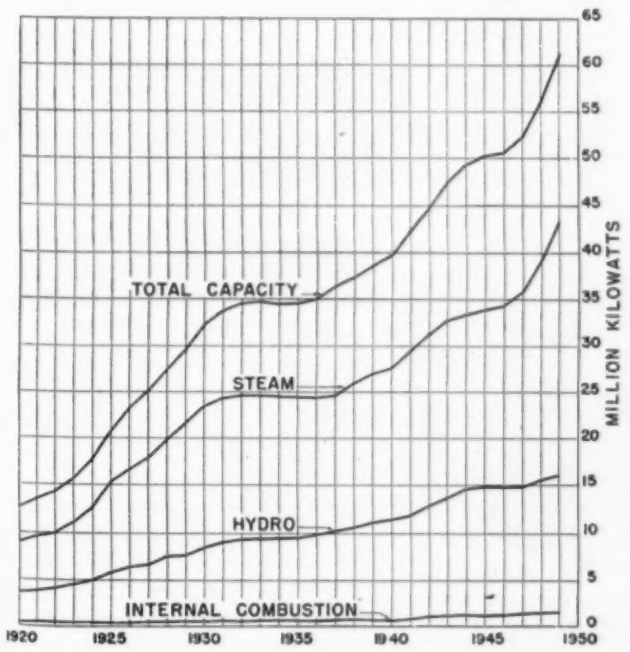

Fig. 1—Increase in installed capacity in last 30 yr

From the foregoing it will be noted that although the number of steam plants is only 27 per cent of the total, they represent approximately 69.5 per cent of the total installed capacity and produced nearly 70 per cent of all the electric energy generated for public use in the United States. The annual 1948 plant use factors were 58.3 per cent for fuel-burning stations and 61.3 per cent for hydro plants.

There are 315 Class A and Class B private utility companies. These account for 98 per cent of the total capacity and include all the important plants, of which there were 670 on January 1, 1949. Bringing this figure up to date by adding those that have gone in service thus far this year, brings the total to around 685. Of these about a fifth are over 100,000 kw.

During 1948, the net increase in utility plant capacity was approximately 4,238,000 kw of which 3,270,000 kw was in steam, 681,000 kw in hydro and 287,000 kw in internal-combustion engines. Scheduled additions through 1952 totaled 16,842,761 kw, made up as follows:

1949 (July–December)	4,249,344 kw
1950	5,239,917 kw
1951	5,432,250 kw
1952	1,921,250 kw

A supplementary monthly report of the Federal Power Commission, covering both private and public plants, shows the total installed capacity of all types (steam, hydro and internal combustion) to have passed 60 million kilowatts, as of September 1,1949. This figure will be further augmented by new installations going into service during the latter part of the year.

The curves of Fig. 1 show the increase in central station installed capacity over the last 30 years.

Further data from the same source, based on returns from some 800 private industrial power plants constituting 85 per cent of the total electric energy so produced and extended to 100 per cent equivalent generation, show a total installed capacity of over 13 million kilowatts. Thus the combined utility and private industrial electric generating capacity of the country, as of September 1, 1949, was approximately 73 1/3 million kilowatts.

Operation

Output of electricity by the utilities (public and private) during the month of August (the latest month for which FPC figures are available at this writing) was over 25 billion kilowatt-hours, the highest August output on record and 3.2 per cent over that of the same month last year. Fuel burning plants accounted for more than 70 per cent of the total. For the 12-month period ending August 31, 1949, the total output exceeded 290 billion kilowatt-hours, or 5.9 per cent over that of the preceding 12 months. In fact, it was the highest total yet attained for a 12-month period. Peak demand was also up, and the largest percentage gain was in the South Central section of the country, comprising the states of Arizona, New Mexico, Texas, Oklahoma, Arkansas and parts of Mississippi and Louisiana. To what extent the steel strike, with its far-reaching effect on many industries, will influence electric load during the fourth quarter of the year is yet to be seen.

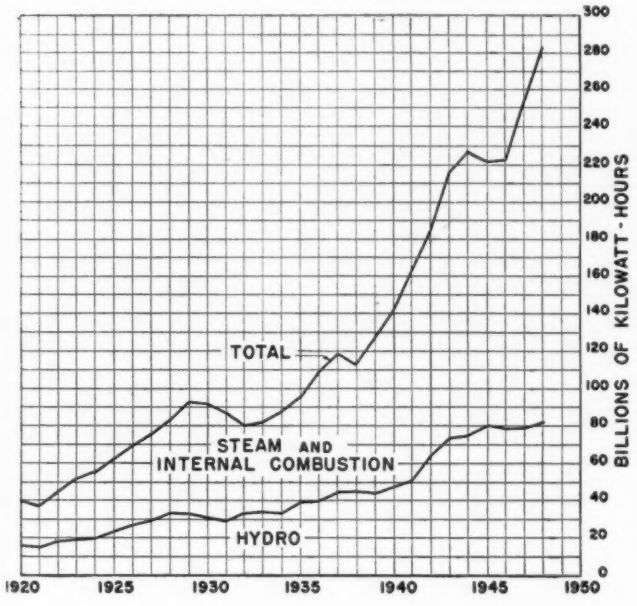

Fig. 2—Output of electric utilities, 1920–1948

Fig. 2, reproduced from the FPC report on Production of Electric Energy in the United States, shows the increase in output by electric utilities from 1920 through 1948. From this it will be seen that the output has doubled in the last 8 yr.

It is of interest to observe that coal consumption by the electric utilities during August 1949, was 17.6. per cent under that of August 1948. While new plants and more efficient equipment undoubtedly were factors in this reduction, the swing to oil and gas probably exerted a greater influence, inasmuch as fuel oil consumption exceeded that of August 1948 by 73.4 per cent and natural gas was up 17 per cent.

The annual average fuel rate per net kilowatt-hour, in coal and coal equivalent, remained at 1.3 lb as of January 1, 1949. For gas and oil the figures were 15.9 cu ft and 0.107 gal, respectively. The 1949 figures, when they become available, will undoubtedly show some decrease in fuel rate due to performance of the more efficient post-war stations and extensions that have gone into service.

In steam central stations, during 1948, fuel accounted for 76.3 per cent of the total production expense and the latter represented 61.5 per cent of the total operating expense, or 34.3 per cent of the revenue from the sale of electricity. These are average figures for the industry.

There were approximately 26 million residential consumers, $4^1/_2$ million commercial and industrial consumers and about 2 million others. This represents an increase of about a third during the last decade, the greatest increase being in the residential class, sales to which account for around 20 per cent of the total energy sold and about a third of the gross revenue.

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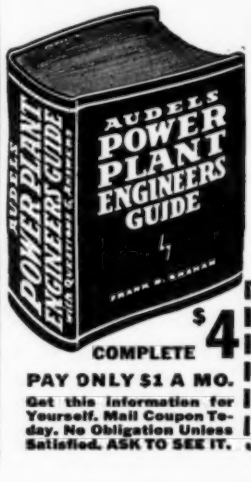

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Court Decisions Concerning Engineers and Power Plants

by LEO T. PARKER

Attorney at Law, Cincinnati, Ohio

Reviewed are cases involving the loan of an employee's services, liability in the case of an independent contractor, state law vs. city ordinances, damages against a union, and protection of an invention.

A RECENT inquiry was as follows:

"We have a suit on our hands. Maybe you can help us. This suit was filed by an injured employee who claims he was burned while repairing a boiler for one of our customers but while being paid by us. We sell, install and repair boilers for steam plants. In this case the employee was injured while temporarily assisting the customer to take fire from another boiler. The customer contends we are solely liable because the man was in our employ and we carry insurance on him under the State Workmen's Compensation Act. Is the customer right?"

The answer is no. This is so because the law is well settled that where an employer lends an employee to another for a particular employment, he must be dealt with as an employee of the man to whom his services are loaned, although he remains the general employee of the person who loaned him. The test is whether, in the particular service which he is engaged to perform, he continues subject to the direction and control of his regular employer, or becomes subject to that of the party to whom he is loaned or hired. See *Puhlman v. Excelsior Company, 103 A. 218, L.R.A. 1918E.*

For another example, in *Spanja v. Thibodaux Boiler Works, Inc., 33 So. (2d) 146*, the testimony showed that The Texas Company employed the Thibodaux Boiler Works to make repairs on a steam boiler. The latter was transporting two pieces of heavy welding machinery to the scene when an employee of The Texas Company was seriously injured while assisting the boiler company to unload the machinery. He sued both The Texas Company and the boiler company for compensation. Both companies carried compensation insurance under the State Workmen's Compensation Act. The injured employee was carried on The Texas Company's pay roll.

The higher court decided that since the employee was taking orders, and under control of the boiler company's foreman when injured, the boiler company was the legal employer and therefore *ordinarily* liable for payment of compensation to the injured employee. In this respect the court said:

"A master may loan his servant, with the latter's consent, to another under such circumstances as to create for the time a new relation of master and servant; the regular servant of one may thus for the time being become the special servant of another, and that was done here."

However, it is important to know that the higher court refused to hold that the boiler company must pay compensation to the injured employee because he was not acting within the scope of the boiler company's regular work when unloading the machinery. This court said:

"Spanja (employee) was the borrowed employee of the Thibodaux Boiler Works, though he remained in the general employ of The Texas Company."

The Supreme Court said that the work was not such as would be done by this employee "in the usual course" of his employment. Also, it explained that an employee hired strictly to repair boilers not to unload machinery cannot recover compensation while unloading or loading machinery.

Now, of course, this decision would have been rendered in favor of the employee receiving compensation had the testimony shown that *regular* employees of the boiler company were protected under the State Workmen's Compensation Act against injuries received while repairing boilers and also while transporting heavy machinery.

Independent Contractor

Higher courts agree that an injured "independent contractor" cannot recover compensation under the State Workmen's Compensation Act. Moreover, he cannot recover damages from his employer unless he proves that the injury resulted from *negligence* of the latter.

In *Wills v. Lehigh Portland, 195 Pac. (2d) 574*, an employer made a contract with a contractor named Wills to perform work on stacks of a steam plant. Wills owned and furnished all tools and equipment used on the job. He worked on the job as weather permitted according to his own methods, and was not under control of the employer. Hence Wills was an "independent contractor."

One day a rope broke and Wills sustained serious injuries. He sued the employer for damages. In holding the employer not liable, the higher court said:

"In doing the work he (Wills) used special rigging, which equipment he owned, and he had complete charge of the work; he was his own boss.... Appellant (employer) cannot be charged with appellee's (Wills') negligence in exercising his own judgment and conclusion."

Wills could not recover compensation under the State Workmen's Compensation Act because independent contractors are not within the scope of this Act.

State Law vs. City Ordinance

Considerable discussion has arisen from time to time over the legal question: When and under what circumstances may a city pass a valid ordinance regulating operators of steam boilers and engines?

According to a recent higher court the fact that a state's laws regulates steam engineers will not prevent a city from exacting additional requirements, or enlarging upon the provisions of the state law. For illustration, in *Brotherhood of Stationary Engineers v. City of St. Louis, 212 S. W. (2d) 454*, it was shown that a state law provides that "any municipal corporation in this state,... shall confine and restrict its jurisdiction and the passage of its ordinances to and in conformity with the state law upon the same subject." Another state law provides that no person "shall be authorized to manage, control, take charge of, or act as engineer of any steam boiler, engine, or apparatus in any city of this state having over twenty thousand inhabitants" who is not a duly qualified engineer. The state law further provides that municipal officials shall grant certificates of qualification to all persons who duly pass an examination before a committee of examiners and are found competent to manage steam engines, boilers, and apparatus.

A city passed an ordinance requiring a person proposing to operate a steam boiler or engine within the city to obtain a license from the Board of Engineers.

This question was presented the court: Can the city compel members of the Brotherhood of Stationary Engineers to obtain licenses? In other words, the primary question was whether the city ordinance for the licensing and regulation of stationary engineers is inconsistent with the above-mentioned state laws.

The higher court held that members of the Brotherhood of Stationary Engineers must obtain licenses under the city ordinance although this association of local stationary engineers was incorporated in 1882. The courts said:

"Not only is the state concerned with seeing to it that steam boilers and engines be under the charge of qualified persons, but a city may have a similar concern.... The City of St. Louis enacted the ordinance in question, which enlarges upon the provisions of the state law by requiring more than the state law requires, but which is in no sense in conflict with it."

For comparison, see *Vest v. Kansas City, 194 S. W. (2d) 38*. This case involved the claim that an ordinance of a city was in conflict with the state law. The state law provides that each person to whom a certificate of registration has been issued by the state authorities must be physically examined at least once a year. The ordinance requires the person to be examined once every six months.

The Supreme Court held that the ordinance was not in conflict with the state law, but merely supplemented it by imposing *additional* requirements for the purpose of enforcing the same standard of fitness as that which the state law exacted.

Also, see *Consolidated, 185 S. W. (2d) 344*. This court said:

"It goes without saying that a municipal ordinance regulating matters and things upon which there is a general law of the state must be in harmony with the state law, and is void if in conflict with it. However, that even though there is a state law on a given subject, a city is not thereby prohibited from enacting a supplemental ordinance in relation to the same subject, so long as there is no conflict between the ordinance and the state law."

Union Liable in Damages

According to a recent higher court a union may be held liable in damages where its members illegally picket a plant.

For example, in *International Union of Operating Engineers, Local v. Cox, 212 S. W. (2d) 1000*, the Velasco Laundry & Cleaners sued the International Union of Operating Engineers for damages. The laundry company alleged that the union illegally picketed its plant with the result of loss of profits and shrinkage in value of its property.

The higher court awarded the laundry company $500 damages, saying:

"Appellee's (laundry company's) business here was shown to have been a going concern and making profits at the time when the 'picketing' by appellants (union) was visited upon it, causing the loss and damages the trial court allowed the comparatively small recovery for."

Boiler Repairman Killed

Under no circumstances can an injured employee recover compensation unless he proves that at the time of the injury he was working for and under control of his employer.

For example, in *Marrie v. Industrial Commission, 81 N. E. (2d) 300*, the testimony showed facts, as follows:

A man named Hartwell during his lifetime was an employee of the boiler company as a repairman. He worked for this company for a period of about thirty years. During the last year of his life he was not regularly employed, but from time to time, as his services were needed, he was assigned by the company to particular repair jobs at the plants of various customers.

Hartwell had not been discharged or retired by the boiler company, nor had he quit or resigned his employment, but was still subject to call by that company.

One day an old customer phoned Hartwell to come and do some work. In the meantime the customer's engineer who was in charge of repair work in the boiler room had his workmen cool the boiler and remove the back circulating tube. The customer also procured a new circulating tube to be installed in the place of one that had fractured. Some of the tools brought by Hartwell to the job bore the boiler company's label.

When Hartwell arrived, the customer's engineer instructed him not to enter the boiler for about half an hour because it was still warm. But, disregarding these instructions, Hartwell went into the boiler soon after his arrival, and while there he suffered heat prostration which resulted in his death three days later.

Dependents of Hartwell sued the boiler company to recover compensation under the State Workmen's Compensation Act.

The higher court refused to award compensation because the testimony showed that the boiler company had

no knowledge that Hartwell was doing the repair job. The court said:

"The law indulges no presumption that one performing work for another is either a servant or an independent contractor, and where a party injured claims that at the time of the injury he was such an employee, the burden is upon the claimant to prove by the greater weight of the evidence that he was such employee at the time of injury."

Patent Law

Recently an engineer asked this question: "Quite often I have good ideas for patents, but don't want to spend $150 or so to file an application. How can I protect my inventions against misappropriation or theft without filing an application for a patent?"

There is no plan by which an inventor can have protection against appropriation of his invention, except to file the application in the United States Patent Office. Therefore, if an inventor has perfected his invention the safest and best plan is to file an application for a patent. If, on the other hand, the inventor has not perfected the invention here are the proper things to do: First, purchase a book and make *written* notes and *explanations* of *every* experiment, and *date* these various sheets. Occasionally it will be advisable to permit a dependable person to witness an experiment, in which case his name and address should be written on the dated sheet on which the experiment is explained. When the device is perfected the inventor may then file an application for a patent. In the United States the owner of an invention, and the one who has a legal right to the patent, is the person who was *first* to invent it and make the invention operate. Hence, a person may obtain a patent, but if he is not the original inventor he is *not* the legal owner of the patent and the person who *first invented* the device may appeal to the court which will take the patent from the one to whom it was wrongfully issued, and award the patent to the original inventor if the latter did not delay too long in filing his application for a patent. See *Richmond Screw Anchor Company v. Umbach, 173 Fed. (2d) 521.*

Jury Must Decide

Modern higher courts consistently hold that law suits involving injuries to persons and property must be decided by a jury whose decision will not be reversed unless proof is given that such decision was not based on the prosecuted evidence and testimony.

For example, in *Salva v. New Asphalt Company, 50 Atl. (2d) 635,* it was shown that one Salva was seriously injured while on the premises of that company when a steam boiler owned and operated by it exploded. A great amount of testimony was given but finally the jury decided that the asphalt company's officials were negligent in failing properly and frequently to hire competent employees to inspect the boiler and make necessary repairs. Therefore, the jury awarded Salva $8500 damages. The company appealed to the higher court and asked it to reverse the verdict for the following reasons: (1) the verdict was the result of bias, prejudice, passion, mistake, and grossly excessive; (2) the verdict included an improper or illegal element of damage; (3) the verdict was excessive.

The higher court refused to reverse the jury's verdict saying that its decision was based on reliable and competent testimony.

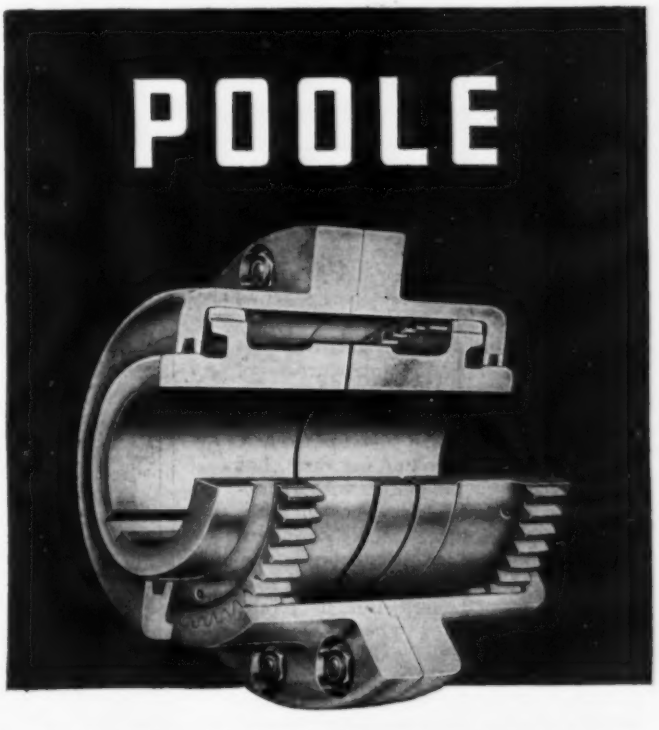
G. I. Is Killed

Considerable discussion has arisen from time to time over the legal question: If a G. I. on Government training is killed or injured what compensation would be forthcoming?

In *Wood Company v. Cole, 209 S. W. (2d) 290,* it was shown that a G. I. named Cole qualified for United States Government subsistence payments under the G. I. Bill of Rights. He was classified as a mechanic. Cole's beginning wage was $50 per month. He received in addition to the $50 per month from the company subsistence payment from the Government of $90 per month.

Cole was later killed. This question was presented the court: On what salary basis can compensation under the State Workmen's Compensation Act be paid to Cole's dependents? This court allowed compensation based on a salary of $140 per month, and said:

"...The subsistence allowance of $90 per month paid to Cole by the Government must be considered as part of Cole's wage within the meaning of the Compensation Law and when this sum is added to $50 per month paid by the company, Cole's total wage was $140 per month, which entitled the claimants to compensation at the rate of $20 per week."



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Fuels Conference Features Design Factors and Coal Preparation

THE Twelfth Joint Fuels Conference of the A.S.M.E. Fuels Division and the A.I.M.E. Coal Division was held at French Lick Springs Hotel on October 26 and 27, the program including technical sessions on steam generator design, fuel-burning equipment and coal preparation. Space here permits reporting only the first group of papers, namely, "Steam Generator Design as Influenced by Available Fuels and Fuel Quality," by **Dr. John Van Brunt** of Combustion Engineering-Superheater, Inc.; "Fuel Burning Equipment Developments for Available Coal, Oil and Gas Fuels," by **R. K. Allen** of Babcock & Wilcox Co.; "Some Design Problems of Nuclear Power Plants," by **Ward F. Davidson,** research engineer of Consolidated Edison Company of New York; and "The Use of Ignition Baffles with Single-Retort Stokers," by **T. S. Spicer, R. J. Grace** and **C. C. Wright,** all of Pennsylvania State College.

The papers dealing with coal preparation were: "Moisture with Flash Dryers," by **F. P. Calhoun;** "Operating Data for a Verti-Vane Thermal Coal Dryer," by **Orville R. Lyons;** "Coal Drying in Relation to Coal Preparation," by **John L. Erisman;** "Some Factors Influencing the Froth Flotation of Coarse Coal Particles," by **Shiou-Chuan Sun** and **R. E. Zimmerman;** "Laboratory Control in Coal Washing and Drying Plants," by **J. J. Merle** and **R. A. Mullins.**

Steam Generator Design as Influenced by Available Fuels

Prefacing his remarks with the statement that the modern steam generator is a comparatively recent development, **Dr. Van Brunt** proceeded to review the factors that had led up to its present state.

The first marked improvement in performance, following the introduction of pulverized coal, was due to the introduction of the water screen across the bottom of the furnace to prevent fusion of the ash. This permitted higher burning rates, but the latter caused difficulties with refractory walls and led to water-cooled walls. The increased furnace capacity due to water cooling, in turn, led to larger furnaces and greater capacities with the then standard type of boiler. But, as a rule, the units were designed to burn a specified grade of coal, usually of good quality.

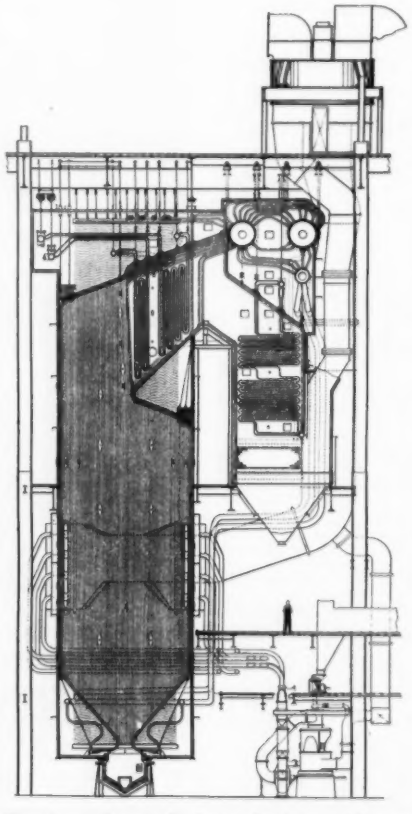
From 1930 to 1940, the majority of additions to utility systems were high-pressure, high-capacity topping units designed for 1350–1400 psi and 900–925 F. During this period, however, competition was keen and many units were installed that would perform well with a good high-fusion ash coal at moderate loads, but at sustained base load for 24 hr daily, or with a lowering of coal quality, fouling of the boiler and superheater was frequent, and reduction in capacity became necessary. Many of these units were installed for furnace heat releases of 20,000 to 30,000 Btu per cu ft—rates that were not prohibitive for small units and high-ash-fusion coal, but too high for large units at sustained maximum loads.

A factor adding to the operating difficulties was the changing coal situation through the gradual depletion of high-grade coal mines and the opening of many strip mines.

The principal causes of slagging were operation with furnace exit temperatures above the ash-fusion temperature and a too high gas velocity through the boiler bank and superheater.

While some manufacturers had tried for greater conservatism in design, competition and tight purse strings on the part of purchasers held back such designs until the hard facts of the cost of keeping boilers free from slag and the cost of outages forced recognition of the fact that prevailing combustion rates were too high. From operating records and test data much information on furnace performance was obtained and this pointed to the solution of the problems.

About this time boiler manufacturers recommended that furnaces be designed to burn any coal available to the purchaser, but this presented no problem with conservative design. Steam temperatures had currently advanced to a maximum of 935–950 F.



Section through late design of large high-temperature, high-pressure, once-through reheat unit

By designing the superheater for two stages and spacing the superheater tubes in the pass nearest the furnace at double the usual spacing, the finishing loops provided wide gas lanes and low gas velocity. The gas at lowered temperature then passed through the primary superheater of more closely spaced tubes without danger of fouling.

After 1941, because of the war, the quality of coal suffered a further decline, but few changes were made in basic design and improvements were largely confined to details. But following the war many large new units were designed for still higher steam temperatures and for operation under the single-boiler, single-turbine arrangement. This called for conservative design, as high availability was most important.

Moreover, the increased cost of coal and the urge for greater economy led to a revival of the reheat cycle, some such installations employing 1050 steam temperature and 1000 reheat.

With reheat, no convection boiler surface is employed, the unit consisting of a furnace, in the walls of which all the steam is generated, a superheater, a reheater, an economizer, and an air preheater. Such units incorporate all the improvements found desirable during the past ten years and include larger furnaces with low combustion and release rates, wide spacing of superheater elements in the high-temperature zone, straight-through gas passages without baffles, low gas velocities and low draft loss, tight settings and ash pits with minimum leakage. Control of steam temperature is had by means of desuperheaters, bypass dampers, burners placed at different elevations or by the use of tilting burners that can be directed upward or downward to, in effect, vary the volume of the combustion zone and thus vary the effective radiant heat absorbing surface of the furnace. Such adjustable burners have also proved effective in controlling the furnace exit temperature.

The illustration here reproduced, which is one of a number shown, illustrates a late design with reheat, steam conditions of 1650 psi, 1000 F steam temperature and 1000 F reheat. It is a once-through design with steam temperature controlled by burner tilting and a desuperheater.

Dr. Van Brunt also referred briefly to fouling of heating surfaces when burning fuel oil at gas temperatures of 1900 to 2000 F and above, and to rapid oxidation and attack of alloy supports by vanadium pentoxide contained in some oils.

Fuel Burning Equipment Developments

Starting with the properties of available fuels, **Mr. Allen** pointed out that with coal the most troublesome problems in design and operation result from the ash and, to a lesser extent, the sulfur in the coal. With oil (usually Bunker C or No. 6 fuel oil) there may be serious slagging and corrosion, despite its relatively low ash and sulfur content. Natural gas, on the other hand, is clean and presents no serious handling problems; in other words, where available at a cost comparable to oil and

coal it is usually considered the most desirable fuel.

Coal ash is primarily composed of compounds containing alumina, silica, calcium, and iron. The state of the iron is largely dependent upon the atmospheric conditions existing during combustion. In an oxidizing atmosphere the iron will be largely oxidized to Fe_2O_3, but in a reducing atmosphere it may be present as Fe_3O_4, or FeO. The fusing temperature of the ash is lowered when it is produced in a reducing atmosphere conducive to the production of FeO.

The temperature required for tapping ash as a molten slag from a slag-tap furnace is related to the melting temperature of the ash in a reducing atmosphere.

To avoid the possibility of slagging and plugging of boiler convection surfaces of pulverized-coal-fired units, it has been found necessary to reduce the true gas temperature entering the convection bank. However, in the author's opinion, the fouling of boiler, economizer and air heater surfaces by coal ash seems to be influenced more by the type of firing equipment than by the quantity of ash in the coal burned.

The ash content of No. 6 fuel oil ranges from 0.04 to 0.15 per cent and the sulfur from 0.5 to 5 per cent. Following are some of the problems they cause:

1. Fluxing of refractory furnace walls.
2. Slagging of superheater surfaces in the 1500 to 1700 F gas temperature ranges, with deposits that are not successfully removed by air or steam soot blowers. Troubles with oil slag were not experienced until the early 1930's. The troublesome oils have been found to be those having an ash high in sodium sulfate and/or vanadium oxide.
3. Coating of boiler, economizer and air heater surfaces.
4. Corrosion of the cold sections of air heaters.

Mr. Allen next described and discussed some of the current types of fuel-burning equipment and furnaces, including spreader stokers, radiant-type boilers, the open-pass boiler, the integral-furnace boiler and the cyclone furnace.

With regard to spreader stokers he stated that approximately 22 per cent of all new coal-fired boiler capacity installed in 1946 was spreader-stoker fired. Despite this, for the same year pulverized coal maintained its place by accounting for 66 per cent of the coal-fired capacity.

Heat release rates in the cyclone furnace proper, he stated, can be maintained above 400,000 Btu per cu ft per hr with excess air of the order of 10 per cent. However, relatively large secondary furnaces are employed to reduce the gas temperature entering the convection surfaces below the initial deformation temperature of the ash.

Nuclear Power

At the Wednesday Luncheon, **Mr. Davidson** discussed some of the design problems of a nuclear power plant. While there appear to be no unsurmountable technical barriers to the development of large nuclear power plants, it was, in his opinion, by no means clear that such plants can offer anything like as great economic advantages as have been predicted. In

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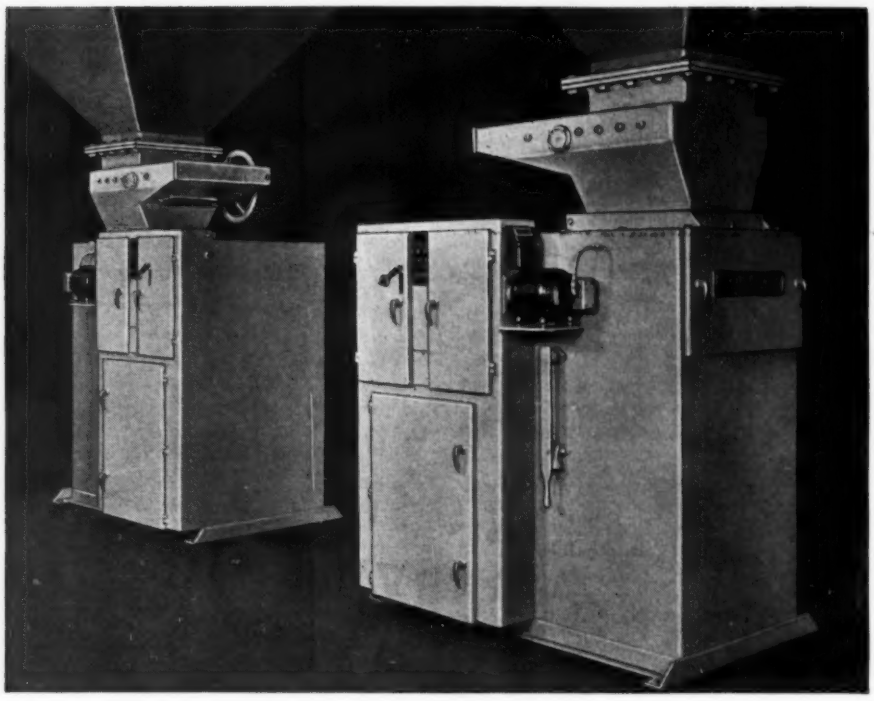

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fact, the outlook as to costs, even if the enormous development expense be charged to other projects, is such that one would not expect rapid large-scale inroads of nuclear power into the field of industrial power production. At most, he believed, nuclear power plants might at some future time represent a substantial portion of new capacity and thus be a supplement rather than a substitute for power from coal, oil, gas, and water power.

At present, no method is known, nor has any been suggested by competent scientists, for the direct production of electric power from the energy released by nuclear fission. On the other hand, vast quantities of heat, equivalent to the output of many thousand kilowatts, are now being carried off as waste from nuclear reactors used for the production of materials for bombs. The technical problem is to modify the reactor so that the heat from it can be used in a turbine to drive an electric generator. Some of the difficulties in bringing this about were reviewed by Mr. Davidson. One of these is the search for proper materials to withstand neutron bombardment and the radiation intensities.

While the initial cost of a nuclear power plant might run to from two to three times that of a modern high-efficiency, coal-burning plant, it is conceivable that the fuel cost might be far lower, if ample supplies of uranium ores are discovered and if it is found possible to reduce greatly present cost of reclaiming and reprocessing the partially spent uranium. But under present conditions uranium as a fuel for power plants is much more costly than coal. At some later date, thorium may become an alternative to uranium.

Other considerations include the hazard of locating a nuclear power plant near load centers and the problem of disposing of radioactive waste.

Ignition Baffle with Single-Retort Stoker

Professor Spicer described work that had been carried on at Pennsylvania State College in which an arch or baffle placed some 22 in. over the fire bars of a single-retort stoker had resulted not only in quick ignition but had made possible operation at much higher rating with substantial fuel savings. The baffle, which is 38 in. wide, extends only over the width of the fire bed (about half the furnace width) but runs from the front wall to the bridgewall of the hrt boiler. The flames pass around and over it. Only its supporting members are water cooled.

Inasmuch as coal is a poor conductor of heat, the temperature a short distance beneath the surface is low without the baffle, but due to the radiant heat from the baffle penetration is greater; hence ignition is more rapid.

Tests have shown it possible to increase burning rates 50 per cent, efficiency 4 per cent and to effect a marked reduction in smoke when burning green bituminous coal. No firing tools are used. The cost was approximately $200, and a $500 saving was effected during the first year.

A companion 178-hp boiler in the heating plant and laboratory has not yet been so equipped, hence serves for comparison.

In fact, it is possible to carry nearly twice the load on the baffled unit.

In discussing the paper, **Otto de Lorenzi,** of Combustion Engineering-Superheater, Inc., showed colored moving pictures of this and the companion furnace when burning a caking coal. The contrasts were striking with many dark areas and blow holes showing in the unbaffled furnace, whereas the fuel bed of the baffled furnace appeared uniformly ignited.

Economic Conditions in Britain

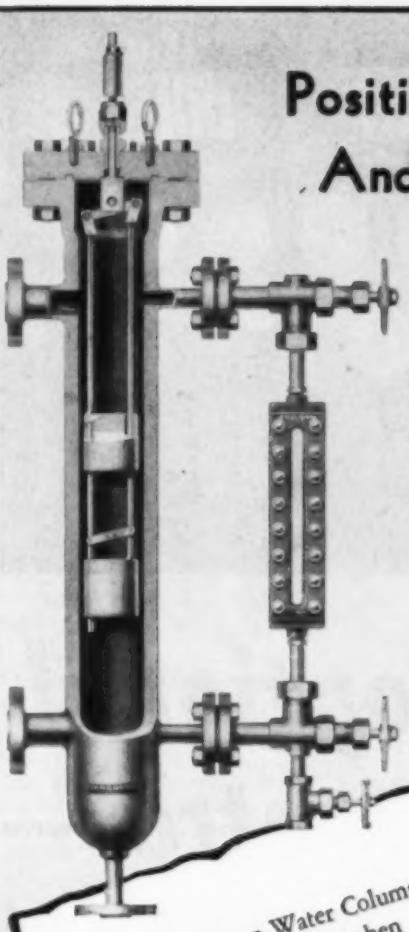
Speaking at the banquet **Russell I. Richardson,** a member of the Indiana Legislature, reported his observations during a two-month tour of various sections of Great Britain, made to obtain first-hand information on the economic conditions in that country. In order to get a cross-section of opinion he visited Parliament, talked with government officials, miners, factory workers, small merchants, clerks, editors, home owners and patrons in shops, restaurants, etc. He found the British people to be burdened with many acute shortages, extremely heavy taxes, high indebtedness and less economic freedom under their socialist government than any other people in Europe, outside the communistic-dominated countries. Their outlook was dismal.

Income taxes have been averaging 45 per cent and upward, depending upon the bracket into which one's income falls; and purchase taxes on many items, except food and housing, run as high as 100 per cent. The profit motive has practically disappeared, for numerous subsidies are provided by excessive taxation and paid from the public treasury to redistribute wealth to the exclusion of those who helped to produce and accumulate it. There are imposed government directives, regulations and controls, so as to make the population dependent upon and subservient to the government. A program of controlled jobs, wages, health service facilities, housing, food supplies, education, and money value is placed in the hands of government officials.

Mr. Richardson told the Conference that one of the most significant powers, to carry out the program of the present government, has vested in the hands of the Ministers of the Crown the right to declare and issue "statutory instruments," which are orders that have all the force of law and cannot be challenged in the courts. Similar to this is a "Control of Engagements" order under which every man and woman between the ages of 18 and 50 can be directed by the State to take any job, anywhere, at any time, according to the State's choice. This order was saddled on the British people in1947.

Percy Nicholls Award

Also at the banquet the 1949 Percy Nicholls Award was conferred upon L. A. Shipman, combustion engineer for the Southern Coal and Coke Company, Knoxville, and a member of both the A.S.M.E. and the A.I.M.E. The presentation was made by Julian E. Tobey, president of Appalachian Coals, Inc. This is a joint award by both societies for "notable scientific or industrial achievment in the field of solid fuels."



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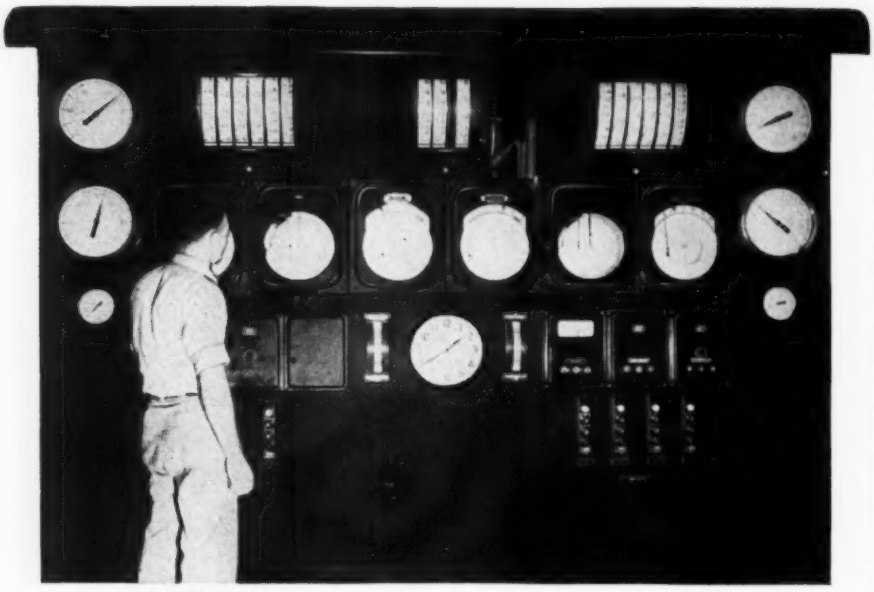

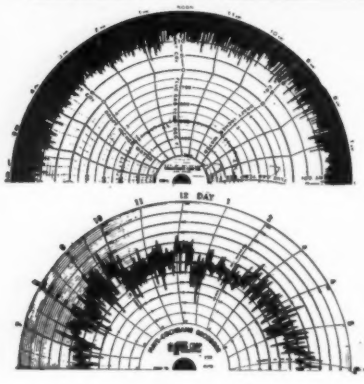

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A.S.M.E. Annual Meeting Program Briefed

THE theme of the 1949 Annual Meeting of The American Society of Mechanical Engineers, to be held at the Hotel Statler, New York, N. Y., November 27–December 2, 1949, is "The Engineers' Contribution to a Peaceful World."

On the program are 74 technical sessions and more than 300 engineering papers, as well as a number of luncheon talks and social events. The first Wright Memorial Lecture in honor of the late Roy V. Wright will be delivered on Tuesday by the Chief Justice of the New Jersey Supreme Court, Arthur T. Vanderbilt, who will speak on "Standards for Citizenship." H. J. Gough, president of the Institution of Mechanical Engineers, (Great Britain), as a guest and will speak along with A.S.M.E. President James Todd at the annual dinner and honors night on Wednesday, November 30.

Only those papers pertaining to the steam power field have been noted in the following listing. Since the program is a tentative one, persons planning to attend specific sessions will find it advisable to confirm dates and times by contacting A.S.M.E. Headquarters prior to making the trip to New York.

Papers of interest to those in the power field are scheduled as follows:

Monday, Nov. 28, 2:30 p.m.

"Survey of Work on Escher Wyss-AK Closed-Cycle Gas Turbines 1945–1950," by Curt Keller, Escher Wyss Engineering Works, Zurich, Switzerland.

"Pyrometer for Measuring Total Temperature in Low-Density Gas Streams," by E. P. Walsh, Westinghouse Electric Corp., and Sidney Allen, Armstrong Siddeley Motors, Conventry, England.

Tuesday, Nov. 29, 9:30 a.m.

"A 4000-Hp Gas-Turbine Locomotive for Passenger Service," by W. A. Brecht and T. J. Putz, Westinghouse Electric Corp.

"Gas-Turbine Power Plants in Locomotives," by R. A. Williamson and A. H. Morey, General Electric Co.

Tuesday, Nov. 29, 2:30 p.m.

"The Outlook for Ceramics in Gas Turbines," by I. E. Campbell and W. H. Duckworth, Battelle Memorial Institute.

"Metallurgy of Gas-Turbine Materials," by N. Mochel, Westinghouse Electric Corp.

"Philadelphia Electric Company Adopts Mobile Coal-Handling Equipment," by Everett C. Russell, Philadelphia Electric Co., Philadelphia, Pa.

"Storing and Reclaiming Coal With Earth-Moving Equipment at the Oswego Steam Station," by J. N. Ewart, Buffalo Niagara Electric Corp.

Tuesday, Nov. 29, 8:15 p.m.

"Design of Regenerators for Gas-Turbine Service," by D. Aronson, Elliott Co.

"Notes on Heat-Recovery Equipment for Gas Turbines," by D. M. Schoenfeld, Combustion Engineering-Superheater, Inc.

"Gas-Turbine Regenerators: Some Economic and Design Considerations," by H. S. Bimpson and R. A. Wilson, Allis-Chalmers Mfg. Co.

"Allowable Eccentricity of Spherical Heads Convex to Pressure," by R. G. Sturm and L. W. Smith, Purdue University, and H. L. O'Brien, Graver Tank and Mfg. Co.

"Mechanical Testing, Experimental Stress Analysis and Apparatus in Pressure-Vessel Research," by F. G. Tatnall, The Baldwin Locomotive Works.

"Effect of Welding on Pressure-Vessel Steels," by A. F. Scotchbrook, L. Eriv, R. D. Stout and B. G. Johnston, Lehigh University.

Wednesday, Nov. 30, 9:30 a.m.

"Heat-Exchange Equipment for a 5000-Kw Gas-Turbine Generator," by George R. Fusner, General Electric Co.

"The Evaluation of Steam Power Plant Losses by Means of the Entropy-Balance Diagram," by Allen Keller, General Electric Co.

"Mechanical Design and Testing of Long Steam-Turbine Blading," by H. M. Owens and W. E. Trumpler, Jr., Westinghouse Electric Corp.

Symposium: Fly-Ash Utilization:

"The Present and Future Magnitude of the Pulverized-Coal Fly-Ash Disposal Problems," by Henry S. Walker, The Detroit Edison Co.

"Use of Fly Ash in Concrete," by Walter Handy, Combustion By-Products Co.

"Some New Developments in the Use of Fly Ash," by M. C. Randall, Sr., Philadelphia Electric Co.

"Use of Fly Ash in the Bitumastic Road Industry," by C. N. Weinheimer, The Detroit Edison Co.

Wednesday, Nov. 30, 2:30 p.m.

"Some Factors Influencing the Economics of Reheat Installation," by H. A. Wagner and R. W. Hartwell, The Detroit Edison Co.

"Selection of Steam Conditions for No. 4 Unit—Riverside Generating Station," by R. C. Dannettel and G. S. Harris, Consolidated Gas, Electric Light and Power Co. of Baltimore.

"A Comparison of Costs of Reheat Versus Non-Reheat for 100-Mw Units," by R. P. Moore, Buffalo Niagara Electric Corp.

"Effect of Pressure on the Combustion of Pulverized Coal," by T. T. Omori, California Institute of Technology, and A. A. Orning, Carnegie Institute of Technology.

"Continuous Gasification of Pulverized Coal With Oxygen and Steam by the Vortex Principle; A Progress Report," by H. Perry, R. C. Corey, and M. A. Elliott, Bureau of Mines.

Thursday, Dec. 1, 9:30 a.m.

"Heat Transfer to Superheated Steam at High Pressures," by W. H. McAdams, Massachusetts Institute of Technology, W. E. Kennel, Standard Oil Co. of Indiana, and James N. Addoms, Massachusetts Institute of Technology.

"Possibilities of the Regenerative Steam Cycle at Temperatures up to 1600 F," by P. H. Knowlton, General Electric Co., and R. W. Hartwell, The Detroit Edison Co.

"Turbine-Oil Maintenance and Purification Problems," by H. J. Klotz, Stone and Webster Engineering Corp.

Thursday, Dec. 1, 2:30 p.m.

"Furnace Heat Absorption in Pulverized-Coal-Fired Steam Generator, Using Turbulent Burners at Paddy's Run Station, Louisville, Ky."

Part I. Variation in Heat Absorption Shown by Measurement of Surface Temperature of Exposed Side of Furnace Tubes, by R. I. Wheater and M. H. Howard, Foster-Wheeler Corp., A. G. Rosenbaum and F. B. Tetzel, Louisville Gas and Electric Co.

Part II. Furnace Heat Absorption Efficiency as Shown by the Temperature and Composition of Gases Leaving the Furnace, by R. C. Corey and Paul Cohen, Bureau of Mines.

Part III. Comparison and Correlation of the Results of Furnace Heat Absorption Investigation, by H. H. Hemenway and R. I. Wheater, Foster-Wheeler Corp.

Thursday, Dec. 1, 8:30 p.m.

"Vibration of Marine Turbine Blading," by Robert W. Nolan, Newport News Shipbuilding and Dry Dock Co.

"The Design of a Class of 28,000-Ton Tankers," by H. deLuce and W. I. H. Budd, Bethlehem Steel Co.

"Thermodynamic Properties of Mercury Vapor," by L. A. Sheldon, General Electric Co.

"New Measurements of the Heat Conductivity of Steam and Nitrogen," by F. G. Keyes and Dewey J. Sandell, Massachusetts Institute of Technology.

Friday, Dec. 2, 9:30 a.m.

"Hide-Out of Sodium Phosphate in High-Pressure Boilers," by F. G. Straub, University of Illinois.

"Chemical Treatment, Demineralization or Evaporation for Make-Up in High-Pressure By-Product Steam Plants," by J. D. Yoder, The Permutit Co., and W. L. Webb and T. Baumeister, American Gas and Electric Service Corp.

Friday, Dec. 2, 2:30 p.m.

"Sulphite and Silica in Boiler Water at Springdale Station," by L. E. Hankison and M. D. Baker, West Penn Power Co.

"An Automatic Degasser for Steam Sampling in Power Plants," by H. M. Rivers and W. H. Trautman, Hall Laboratories, Inc., and G. W. Gibble, Arabian-American Oil Co.

Items of General Interest

Monday, Nov. 28, 12:15 p.m.—President's Luncheon

Presiding: James M. Todd, president, A.S.M.E.
Speaker: Lillian M. Gilbreth, Gilbreth, Inc.
Subject: "What is Human Engineering?"

Monday, Nov. 28, 8:15 p.m.

"The Obligation of Management to Create a Better Industrial Life—Labor's View," by James B. Carey, secretary and treasurer of the National CIO, Washington, D. C.

"The Obligation of Management to Create a Better Industrial Life—Management's View," by Fred C. Fisher, R. H. Macy, Inc., New York, N. Y.

Tuesday, Nov. 29, 12:15 p.m.—Heat Transfer Luncheon

Speaker: H. C. Hottel, Massachusetts Institute of Technology.
Subject: "Uses of Solar Radiation."

Tuesday, Nov. 29, 2:30 p.m.

"The Continued Education of Engineers in Industry," by J. C. McKeon, Westinghouse Electric Corp.

"Orientation and Training of the Young Engineer in Industry," by J. S. Crout, Battelle Memorial Institute.

Tuesday, Nov. 29, 5:15 p.m.—Roy V. Wright Memorial Lecture

Presiding: James M. Todd, president, A.S.M.E.
Speaker: Justice Arthur T. Vanderbilt, Supreme Court of the State of New Jersey.
Subject: "Standards for Citizenship."

Tuesday, Nov. 29, 8:15 p.m.

Symposium: Junior Engineer—1950:

"What the Large Corporation Offers the Junior Engineer," by M. M. Boring, General Electric Co.

"A Professional Compass for Young Engineers," by Crosby Field, Flakice Corp.

"Employment Outlook for Engineers," by R. R. Behlow, Department of Labor.

Wednesday, Nov. 30, 12:15 p.m.—Fuels Luncheon

Speaker: Richard Harkness, Washington correspondent, National Broadcasting Co.
Subject: "Behind the Scenes in Washington."

Wednesday, Nov. 30, 6:00 p.m.—Annual Dinner and Honors Night

Subject: "May We Co-Operate?"
Speakers: H. J. Gough, president, The Institution of Mechanical Engineers, London, and James M. Todd, president, A.S.M.E.

Thursday, Dec. 1, 9:30 a.m.

Symposium: "Attracting Mechanical-Engineering Graduates to the Railroad Industry."

Thursday, Dec. 1, 6:00 p.m.—American Rocket Society Dinner

Speaker: Dan A. Kimball, Under Secretary of Navy, Washington, D. C.
Subject: "The Complexities of Peace"

Thursday, Dec. 1, 8:15 p.m.

"Recognition of the Engineer," by G. M. Muschamp Brown Instrument Co.

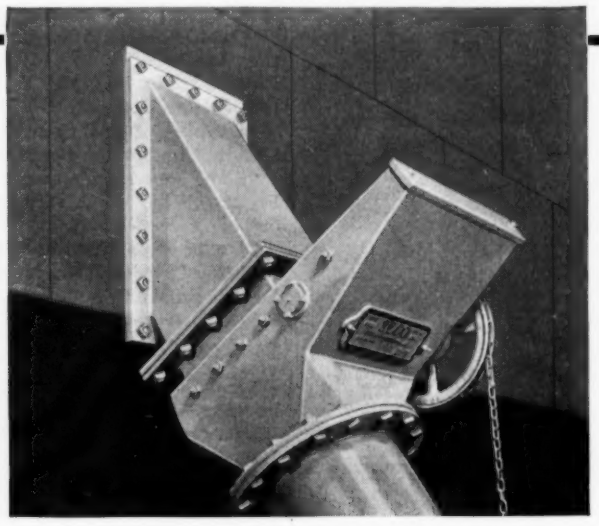
Reunions for mechanical engineers have been scheduled for Thursday, December 1, by the following colleges: University of California, Clarkson College of Technology, Cooper Union, Cornell University, Georgia Institute of Technology, Harvard University, University of Illinois, University of Michigan, New York University, Northeastern University, Purdue University, Rensselaer Polytechnic Institute, Stevens Institute of Technology, University of Wisconsin, and Worcester Polytechnic Institute.

"Point Four" Exemplified

A definite step in the direction of exporting American technical "know-how" along the lines proposed by President Truman in Point Four of his inaugural address and recently presented to Congress has been taken by Combustion Engineering-Superheater, Inc., New York, in a program of cooperation with one of Italy's largest industrial companies, Franco Tosi, S.p.A. of Legnano. The technical assistance rendered by the former will enable the latter to meet more adequately the Italian need for steam generating equipment. It will also further the purposes of the Marshall Plan, in that certain subcontracting work for steam generating units, previously purchased from Combustion under the Economic Cooperation Administration, will be carried on in Italy. This work will provide immediate employment, thus helping to absorb Italy's labor surplus and to combat the efforts of communistic elements to regain the ground lost in last year's elections.

The program provides for the communication of technical and manufacturing information, such as drawings, test data and material specifications. Thus, the Italian firm will have available the same type of information that is used in conducting American manufacturing operations. Provision is also made to undertake development work for Franco Tosi, including the furnishing of technical experts to carry out such work abroad.

Interchange of technical information will be facilitated by Franco Tosi's assignment of resident representatives to Combustion plants in the United States, their function being to study directly the methods of manufacture that are employed here. Reciprocally, American engineers may visit and study the operations of Franco Tosi in Italy, and that information may, in turn, be utilized in this country. The Franco Tosi organization, besides being a large builder of boilers since 1881, operates large shipyards at Taranto and is Italy's leading producer of diesel engines.



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Smoke Abatement in New York City

As a part of National Smoke Abatement Week, October 23–29, a special Public Education Conference was held in the Engineering Societies Building, New York, on October 27 and 28 under the auspices of the Mayor's Committee of the A.S.M.E., the National Association of Power Engineers and the American Society of Heating & Ventilating Engineers. Attendance for the technical sessions over a two-day period was in the neighborhood of a thousand and the conference, in the words of A.R. Mumford, vice president of A.S.M.E., "marked a milestone of cooperation between the engineering societies and the city government."

Separate panel discussions were presented on bituminous coal, anthracite, fuel oil, incinerators, marine problems, public utilities and general instrumentation for smoke control. The conference was climaxed by addresses by Deputy Mayor John J. Bennett, Councilman Joseph T. Sharkey, sponsor of the recently adopted smoke-control law, Commissioner Bernard J. Gillroy of the Department of Housing and Buildings, the city agency responsible for smoke control, William H. Byrne, director of the Bureau of Smoke Control and W. E. E. Koepler of the Smoke Prevention Association of America.

At the opening session of the conference Roderick Stephens, a public relations counsellor, keynoted the theme of National Smoke Abatement Week, "Smoke has no defense." He stressed conservation benefits to be derived from more efficient fuel burning and emphasized that the public will demand elimination of both flyash and smoke. Acknowledging the importance of education in obtaining cooperation to improve firing and combustion practices, the speaker also noted that rigid enforcement of smoke-control laws is important. Much of the discussion on bituminous coal which followed concerned methods of burning low-volatile coking coals in apartment-house furnaces. In this connection the human factor was stressed, with particular reference to the art of firing coal.

E. E. Finn and Paul F. White of the Anthracite Institute took a leading part in the anthracite panel. Noting that this fuel has no difficulty in meeting the most stringent smoke-control laws, Mr. Finn observed that most smoke offences can be overcome by education. To aid toward this end he announced the inauguration of a Smoke Prevention Clinic sponsored by his organization. Mr. White, after tracing the effect of stream anti-pollution laws upon the supply of anthracite, devoted the major portion of his remarks to a comparison of the types of stokers most satisfactory for the burning of anthracite. He also mentioned the burning of anthracite-bituminous mixtures and the development of stokers capable of using the smaller sizes of anthracite.

During the fuel-oil panel F. M. Van Deventer of the Walworth Company took issue with some of the official findings relative to the 1948 disaster in Donora, Pa. He observed that, in the case of the type of inverted atmospheric conditions peculiar to that disaster, wherein there was practically no air movement for two days while a blast furnace continued to emit carbon monoxide, it is difficult to understand why the medical reports did not stress carbon monoxide poisoning. At the same session William G. Christy, smoke abatement engineer of Hudson County, N. J., emphasized the importance of adequate instrumentation in order to burn oil smokelessly. Other precautions include proper service and maintenance and an ample air supply for combustion. At the session on general instrumentation, Professor Kenneth J. Moser of Stevens Institute discussed the principal instruments that can be used for smoke and draft control. There was also a demonstration showing the effect of stack diameter upon the visual appearance of smoke.

Public Utilities Panel

There were three speakers forming the public utilities panel. G. R. Milne, mechanical engineer of Consolidated Edison Co. of New York, told of the problems in operating a large central station without smoke emission and outlined the program now being undertaken to minimize smoke and flyash emission. The only practical means to control smoke is to have sufficient boiler capacity and adequate controls. Under a long-range program Consolidated Edison is equipping all stoker-fired boilers with collectors or supplementing them with oil firing. All new boilers are fired with pulverized coal or oil and have electrostatic precipitators and, sometimes, mechanical collectors as well. When the present work is completed, nearly $21,000,000 will have been spent since 1937 for cinder-catching equipment.

J. C. Falkner, manager of production of the same company, told of operating procedures to minimize emission of smoke and flyash. Some idea of the magnitude of the problem may be understood by realizing that as many as 140 boilers may have to be started during a two-hour early morning period. Each boiler has an output which, if exceeded, will result in smoke discharge, and it is the function of the system operator, wherever possible, to assign loads with this limitation in mind.

Finally, A. B. Boland of the Long Island Railroad Company told of steps being taken to dieselize the motive power of that railroad. When this program is completed there will be about 30 steam locomotives left on the line, of which 16 will be for use in snow removal. This should reduce smoke to the point where it can no longer be considered a nuisance.

Store and Reclaim Coal for few cents per ton.....

Small Sauerman Scraper with back-posts as tail end.

SAUERMAN Scrapers are on record as handling coal for under 3¢ per ton at large power plants and for only slightly more at small plants.

This operating economy is just one of many reasons why SAUERMAN Scrapers have become the most widely used equipment for storing and reclaiming coal. Other reasons are:

- Machine is simple and easy to operate. From a station overlooking the storage area the operator controls every move of the scraper through a set of automatic controls.
- The equipment is adaptable to any ground regardless of the shape or condition of the area.
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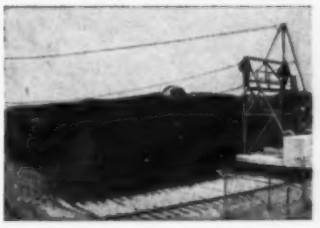

Large Sauerman Scraper with self-propelled tail tower.

If you have any coal storage problem write for the SAUERMAN Catalog.

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Navy Gas Turbine Operated at 1500 F

Successful operation with inlet gas temperatures of 1500 F has been accomplished in tests by the Navy on the Allis-Chalmers gas turbine at Annapolis. Installed at the U.S. Naval Engineering Experiment Station in 1944, the elements of this gas-turbine unit have since been operated for more than 3000 hours of rigorous testing, and the unit has been started and stopped more than 400 times. Successful operation of the unit at 1350 F was revealed in 1946, and subsequent tests have included operation for substantial periods at temperatures ranging up to 1524 F.

Performance of the test unit, which includes two gas turbines, an axial flow compressor, a regenerator and auxiliary equipment, has been very satisfactory thus far, the operators report. Despite the high temperatures at which the unit has been operated, there have been no failures of blading in the high-temperature turbine zones, and frequent inspections have revealed no indications that the unit will not have a satisfactorily long operating life.

Heretofore, temperatures as high as 1500 F have only been achieved in short-time tests of turbines operating above their normal design temperatures, or in short-life-cycle machines such as aircraft jet engines, in which the advantages of extremely high power concentration in a small volumetric space and very low specific weight offset the reduced operating life resulting from the high initial gas temperatures applied to light-weight machines. Thus a great deal of previously unavailable information is being obtained from the tests on the Annapolis equipment.

Among the many design innovations being tested in this installation are various methods of applying cooling air whereby high-temperature parts may be cooled to protect them against undue weakening effects of extremely high temperatures. Probably the greatest significance in the successful operation of this unit at a temperature as high as 1500 F lies in the importance of high-temperature operation as a means of increasing gas turbine thermal efficiency.

New British Power Station

The first section of a new 180,000-kw British power station at Walsall was officially opened on September 30. It is the second of 38 new stations to go into service under the 1947–1952 building program of the Central Electricity Board. Described fully in the October 7 issue of *Engineering*, it is believed COMBUSTION readers may be interested in some of its features as depicting certain post-war British power practices.

The present capacity is 60,000 kw in two 30,000-kw, 3000-rpm turbine-generators and a third is expected to go in service by the end of the year; another of like size is scheduled for 1950 and two more for 1952. Each turbine-generator is served by two 180,000-lb per hr (maximum capacity) boilers with steam at 600 psi, 850 F. These boilers are of the high-head, straight-tube, sectional-header type, equipped with economizers and fired by traveling grate stokers. The calculated furnace heat release is 30,000 Btu per cu ft at mean continuous rating and the net overall efficiency, including economizer, is 81.5 per cent at the most economic rating of the unit.

The turbines are of the two-cylinder, impulse-reaction type with 22 high-pressure stages and 7 double-flow, low-pressure stages, each exhausting to twin condensers.

As is customary with many British stations the condenser circulating water is cooled by cylindrical towers placed over ponds. There are four of these in the initial installation.

Suggests Redevelopment of Niagara Falls

The Federal Power Commission has made public a staff report outlining a possible plan for redevelopment of the United States side of Niagara Falls for hydroelectric power, which would increase the total dependable capacity from the existing 440,000 kw to a total of 1,572,000 kw, with a resultant gain of 7.9 billion kilowatt-hours in the average annual energy production.

The report suggests construction by 1960 of: (1) a lower Niagara unit, in conjunction with the Niagara Falls Power Company's existing Schoellkopf Station, having an installed capacity of about 120,000 kw; (2) a Conners Island-Lewiston unit with an intake in the Niagara River near Conners Island, with waterways serving 1,090,000 kw of generating capacity in the Lewiston power plant; (3) a pump storage unit near the Lewiston plant with a generating capacity of 130,000 kw and (4) control works in the Niagara River located near the Lake Erie outlet.

Estimated cost of the complete redevelopment is $308,700,000, or $350,000,000 depending on the scheme of development selected.

Huge Air Heater

More than thirty miles of $2^1/_2$-in. steel tubing have gone into the giant air heater shown on the cover of this issue while under construction in the Chattanooga, Tenn., shops of Combustion Engineering-Superheater, Inc. The weight of this tubular-type air heater for the Central Arizona Power & Light Co., Phoenix, is 45 tons, and it is 17 ft deep, 32 ft wide and 52 ft high. Total effective heat-transfer area for its 3550 tubes is nearly 105,000 sq ft. When completed it will form part of an outdoor steam generating unit having a capacity of 675,000 lb of steam per hour at 920 psig and 905 F total temperature.

Simplify Your Coal Control

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• You, like the manufacturer shown, can simplify your coal handling, reduce costs and save space by installing a *Beaumont* Coal Handling System.

One man *at one point* controls the System.

The coal arrives by rail, is dumped into hoppers, conveyed by Beaumont Belt Conveyors and discharged either into a bunker for immediate use or down a chute to storage. In the yard, the coal is spread into compact layers—eliminating air pockets and minimizing the hazard of spontaneous combustion.

Tailblocks maneuver the Beaumont Drag Scraper which is operated through remote control. By means of backhaul towers, the coal can be stored to heights of over 100 feet. Beaumont supplies and installs the complete conveying and storage systems—in capacities from 10 to 300 tons per hour.

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